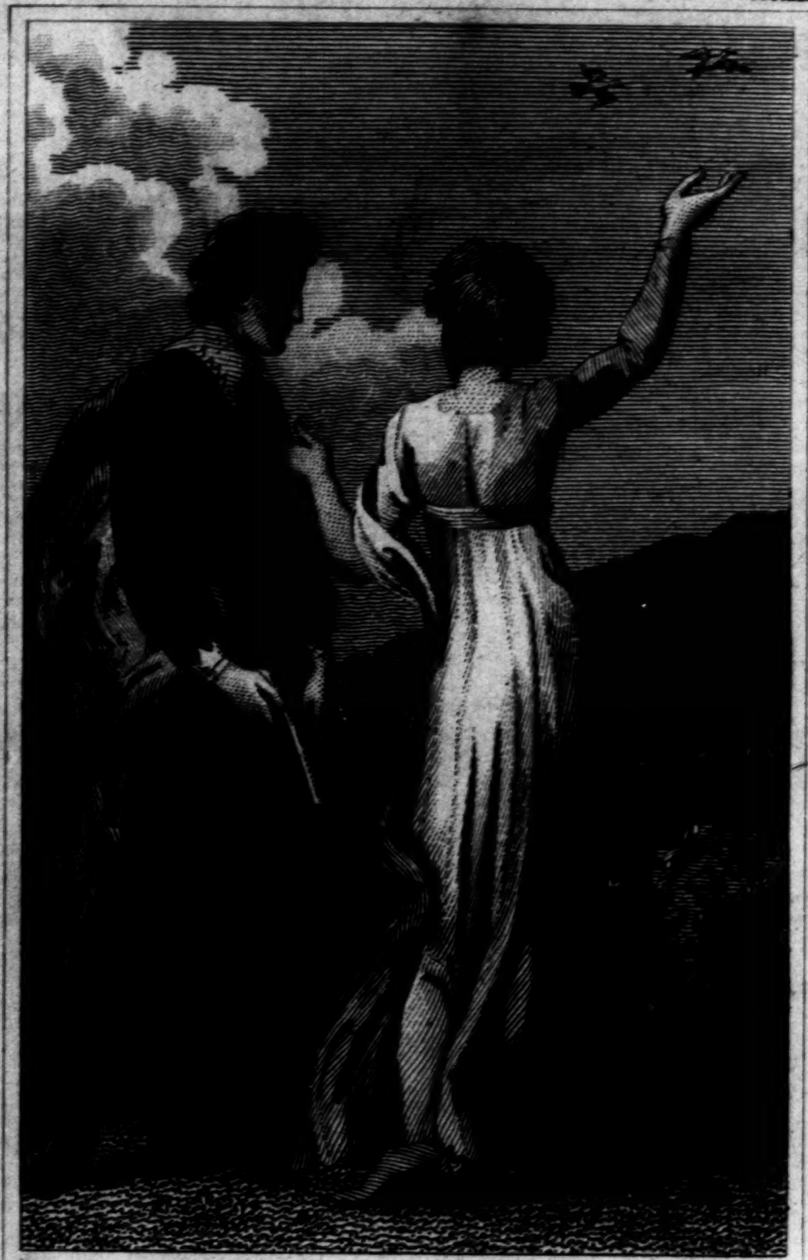
Vol. II



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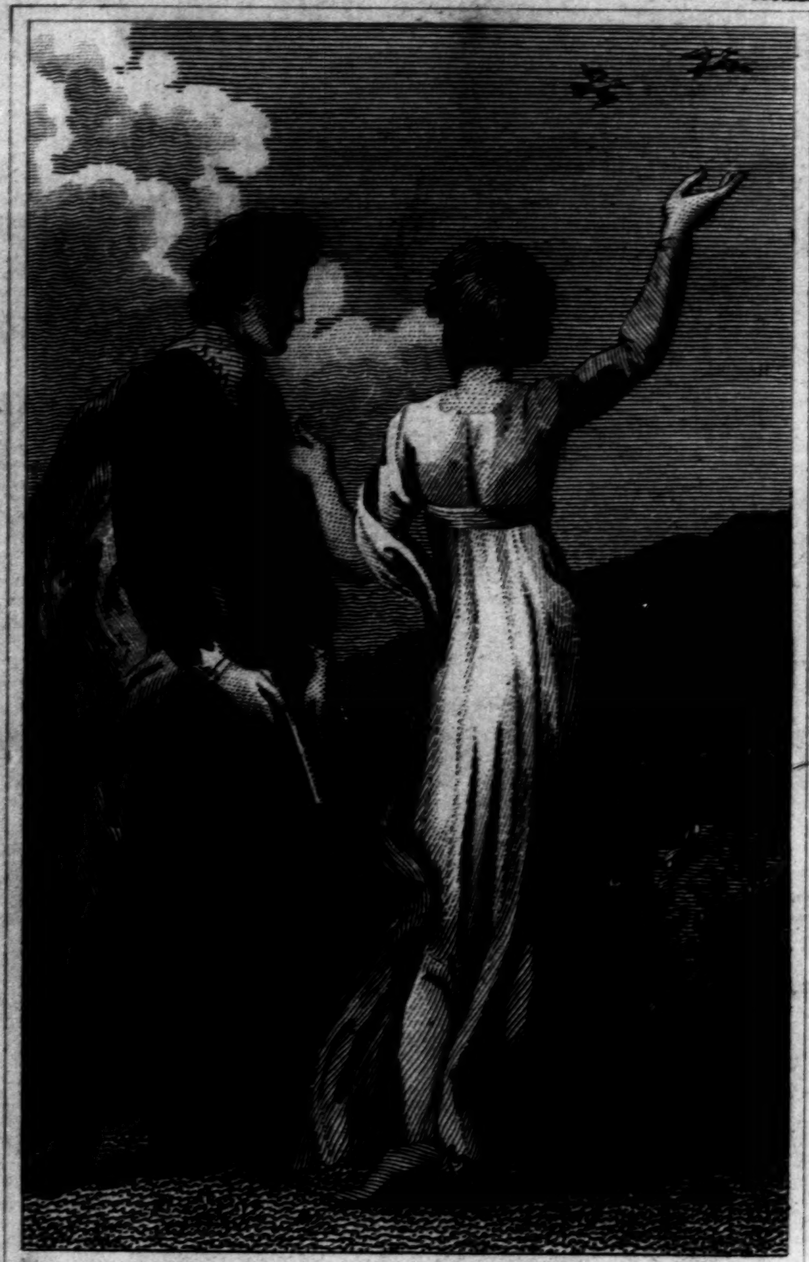

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THE

CONTEMPLATIVE PHILOSOPHER:

OR

SHORT ESSAYS

ON THE

VARIOUS OBJECTS OF NATURE

THROUGHOUT THE YEAR;

WITH

POETICAL ILLUSTRATIONS AND MORAL REFLECTIONS ON EACH SUBJECT.

IN TWO VOLUMES.

VOL. II.

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VOLUME II.

CONTENTS.

THE

CONTEMPLATIVE PHILOSOPHER.

NUMBER XLI.

SUMMER REFLECTIONS.

From brightening fields of ether fair disclosed,
Child of the Sun, refulgent Summer comes,
In pride of youth, and felt through Nature's depth:
He comes attended by the sultry Hours,
And ever-fanning Breezes, on his way;
While, from his ardent look, the turning Spring
Averts her blushful face; and earth and skies
All smiling, to his hot dominion leaves. THOMSON.

IN the month of May the Spring glows with "all the mixtures of colorific radiance", and before the expiration of June that season commences when opening beauty and increasing variety are succeeded by the more uniform scenes of maturity and perfection.

The Summer season, which commences on the twenty-first of June, is so distinguished by a uniformity of character, that, as I have observed before, the great poet of the Seasons has comprised the whole of his description within the limits of a single day. To give importance, moreover, to a season, in other respects so unproductive of subject, his muse

has ſpread her flight to the torrid zone, and enriched her landſcapes with foreign beauties and exotic wonders.

Nature, in our temperate regions, appears in this ſeaſon to have nearly finiſhed her annual work; and ſhe begins to loſe ſomething of her variety. Nothing, indeed, can be more beautiful than the verdure of the orchards and woods, but the ſhades of hue which they exhibit are no longer ſo agreeable. The meadows begin to whiten, and the flowers that adorn them are mowed down. The corn gradually aſſumes a yellow hue, and the colours that decorate the rural ſcene are no longer ſo numerous. How lately did the glowing beauty and variety of theſe, with the notes, as various, of a multitude of birds, diſplay at once all the charms of novelty, and inſpire inexpreſſible delight!

It is in the novelty of objects, indeed, in their appearing at leaſt to be new and uncommon, that the more exquiſite enjoyment of them conſiſts. Novelty excites a pleaſure in the imagination, becauſe it ſtrikes the ſoul with an agreeable ſurpriſe, gratifies its curioſity, and gives it an idea of which it was not poſſeſſed before. It contributes, therefore, to vary human life: it tends to divert and refreſh the mind, and to take off that ſatiety of which we are apt to complain in the entertainments to which we are conſtantly accuſtomed; it is that which gives its charm to variety, where the mind is every inſtant called off to ſomething new, and the attention not ſuffered to dwell too long, and waſte itſelf, on any particular object. Novelty, moreover, improves whatever is beautiful and pleaſing, and makes it afford to the mind a double entertainment.

Hence we may deduce the reaſon why the groves, and fields, and meadows, which, at any ſeaſon of the year are delightful to the view, are never more ſo than in the opening of ſpring, when they are all

new and fresh, with their first gloss upon them, and not yet too familiar to the eye. But in Summer, in proportion as we advance toward Autumn, these pleasing effects insensibly decrease; the song of the nightingale is no longer heard; and that favourite enjoyment of the country, a walk through fields of verdure, becomes inconvenient and unpleasing, on account of the great heat which sometimes prevails.

Yet Summer has still inexpressible charms, and exhibits proofs every day of the unbounded goodness of the great Creator. It is that season of felicity in which he dispenses his blessings more abundantly to every living creature. Nature, after having reanimated and enlivened us by all the pleasures of Spring, is incessantly employed, during Summer, to provide those enjoyments which are most agreeable to the senses, to facilitate the means of subsistence, and to excite in our breasts the correspondent sentiments of gratitude and love.

Agreeably to the method I have adopted, of enriching these discussions with poetical description, I shall here present my readers with the most striking parts of a summer's day, which, not to multiply quotations, I shall select only from the poet of the Seasons.

MORNING.

When now no more th' alternate *Twins* are fir'd,
And *Cancer* reddens with the solar blaze,
Short is the doubtful empire of the Night,
And soon, observant of approaching Day,
The meek-ey'd Morn appears, mother of dews,
At first faint-gleaming in the dappled east:
And, from before the lustre of her face,
White break the clouds away. With quicken'd step,
Brown Night retires: Young Day pours in apace,
And opens all the lawny prospect wide.
The dripping rock, the mountain's misty top,

Swell on the ſight, and brighten with the dawn.
Blue, thro' the duſk, the ſmoking currents ſhine;
And from the bladed field the fearful hare
Limps, awkward: while along the foreſt glade
The wild deer trip, and often turning gaze
At early paſſenger. Muſic awakes
The native voice of undiſſembled joy;
And thick around the woodland hymns ariſe.

* * * * *

But yonder comes the powerful King of Day,
Rejoicing in the eaſt. The leſſening cloud,
The kindling azure, and the mountain brow
Illum'd with fluid gold, his near approach
Betoken glad. Lo! now, apparent all,
Aſlant the dew-bright earth, and colour'd air,
He looks in boundleſs majeſty abroad;
And ſheds the ſhining day, that burniſh'd plays
On rocks, and hills, and towers, and wandering ſtreams,
High gleaming from afar.

FORENOON.

Now, flaming up the heavens, the potent Sun,
Melts into limpid air the high-rais'd clouds,
And morning fogs, that hover'd round the hills
In party-colour'd bands; till wide unveil'd
The face of Nature ſhines, from where earth ſeems,
Far ſtretch'd around, to meet the bending ſphere.

NOON.

'Tis raging noon; and, vertical, the Sun
Darts on the head direct his forceful rays.
O'er heav'n and earth, far as the ranging eye
Can ſweep, a dazzling deluge reigns; and all,
From pole to pole, is undiſtinguiſh'd blaze.
In vain the ſight, dejected to the ground,
Stoops for relief; thence hot aſcending ſteams
And keen reflection pain. Deep to the root
Of vegetation parch'd, the cleaving fields
And ſlippery lawn an arid hue diſcloſe,
Blaſt Fancy's blooms, and wither e'en the ſoul.

Echo no more returns the cheerful ſound
Of ſharpening ſithe; the mower ſinking heaps
O'er him the humid hay, with flowers perfum'd;
And ſcarce a chirping graſshopper is heard
Thro' the dumb mead. Diſtreſsful Nature pants.
The very ſtreams look languid from afar;
Or, thro' th' unſhelter'd glade, impatient, ſeem
To hurl into the covert of the grove.

AFTERNOON.

The Sun has loſt his rage! His downward orb
Shoots nothing now but animating warmth,
And vital luſtre; that, with various ray,
Lights up the clouds, thoſe beauteous robes of heaven,
Inceſſant roll'd into romantic ſhapes,
The dream of waking Fancy! Broad below,
Cover'd with ripening fruits, and ſwelling faſt
Into the perfect year, the pregnant earth
And all her tribes rejoice. Now the ſoft hour
Of walking comes; for him who lonely loves
To ſeek the diſtant hills, and there converſe
With Nature.

EVENING.

Low walks the Sun, and broadens by degrees,
Juſt o'er the verge of day. The ſhifting clouds
Aſſembled gay, a richly-gorgeous train,
In all their pomp attend his ſetting throne.
Air, earth, and ocean ſmile immenſe. And now,
As if his weary chariot ſought the bowers
Of Amphitrite and her tending nymphs
(So Grecian fable ſung) he dips his orb;
Now half immers'd; and now a golden curve
Gives one bright glance, then total diſappears.

* * * * *

Confeſs'd from yonder ſlow-extinguiſh'd clouds,
All ether ſoftening, ſober Evening takes
Her wonted ſtation in the middle air,
A thouſand *ſhadows* at her beck. Firſt *this*
She ſends on earth; then *that* of deeper die
Steals ſoft behind; and then a *deeper* ſtill,

In circle following circle, gathers round,
To close the face of things. A fresher gale
Begins to wave the wood, and stir the stream,
Sweeping with shadowy gust the fields of corn;
While the quail clamours for his running mate.
Wide o'er the thistly lawn, as swells the breeze,
A whitening shower of vegetable down
Amusive floats. The kind impartial care
Of Nature nought disdains: thoughtful to feed
Her lowest sons, and clothe the coming year,
From field to field the feather'd seed she wings.

NIGHT.

Among the crooked lanes, on every hedge,
The glowworm lights his gem; and, thro' the dark
A moving radiance twinkles. Evening yields
The world to Night; not in her winter robe
Of massy Stygian woof, but loose array'd
In mantle dun. A faint erroneous ray,
Glanc'd from th' imperfect surfaces of things,
Flings half an image on the straining eye;
While wavering woods, and villages, and streams,
And rocks, and mountain-tops, that long retain'd
Th' ascending gleam, are all one swimming scene,
Uncertain if beheld. Sudden to heaven
Thence weary vision turns; where, leading soft
The silent hours of love, with purest ray
Sweet Venus shines; and from her genial rise,
When daylight sickens till it springs afresh,
Unrivall'd reigns the fairest lamp of night. [a]

These principal parts of a summer's day, but more particularly morning, evening, and night, have been the favourite theme of poets, from the most remote antiquity. Each has something picturesque and beautiful that affects every sense with unspeakable pleasure; particularly the sight, which is the most perfect and most delightful of all our senses; which fills the mind with the greatest variety of ideas; converses with its objects at the remotest distance;

[a] See Reflections on a Moonlight Scene, in No. xxii.

and continues the longeſt in action without being tired or ſatiated with its proper enjoyments. Beſide the glowing colours of the flowers, and the ſtill enlivening verdure of the woods, the eye beholds an innumerable quantity of fruits, which, by virtue of the ſecret laws of Nature, grow in our fields and gardens, and which, after thus delighting the ſenſe of viſion, may be gathered and preſerved, to contribute to our ſubſiſtence. The flowers preſent to our ſenſes the moſt agreeable diverſity: we not only admire the richneſs of their attire, but the fecundity of Nature in the numberleſs ſpecies of them. What variety too, what beauty in every plant, from the lowly moſs to the towering oak! If we wander from flower to flower, the eye is ſtill unſatiated with the view. If we aſcend the higheſt mountains, pierce into the midnight depth of the groves, or deſcend into the ſpacious vale, we diſcover new beauties ſpread around in wonderful profuſion. Of the infinity of objects that ſtrike the eye, each is different from the other; but each has in itſelf ſufficient beauty to attract and to fix our attention: yonder a diſtant proſpect, terminated by a beautiful horizon; here the rich and variegated landſcape: there herds of cattle and flocks of ſheep; here flowers and plants, "beyond the power of botaniſt to number up their tribes". If we lift up our eyes, we behold the blue concave, refulgent and ſerene. Adverting to the landſcape around, the eye, juſt dazzled by celeſtial radiance, is cheered again by the bright verdure of the fields;

By thee, gay Green!
Thou ſmiling Nature's univerſal robe!
United light and ſhade! where the ſight dwells
With growing ſtrength, and ever-new delight,

THOMSON.

Nor is the ſenſe of *hearing* unaffected by the uni-

verſal charm; it is ſtill enraptured by the muſic of the woods. The murmurings too of the brook, or of the ſilver waves which the river rolls in its majeſtic courſe, are pleaſing to the ear. The *taſte* is gratified by the early fruits that ripen in this ſeaſon, and which, excluſive of their pleaſing flavour, have the moſt cooling ſalutary virtues. The ſenſe of *ſmelling* is delighted with the fragrance diffuſed from all around. In a word, a thouſand objects exerciſe our ſenſes, and excite our ſenſibility. The flocks and herds, nouriſhed by the laviſh hand of Nature, crop the wholeſome herb, to afford us nutriment and clothing. Kindly rains bedew the ſoil with plenty, and open new ſources of thankſgiving. The tufted trees and bowery thickets refreſh us with their welcome ſhade. Whatever we *ſee*, and whatever we *hear*; whatever can delight the *taſte*, or the ſenſe of *ſmelling*, augments the number of our pleaſures, and contributes to felicity.

But a view of the creation at this ſeaſon is ſtill more enchanting, when conſidered as a ſource of pleaſure to the underſtanding, which diſcovers what the ſenſes cannot attain: it contemplates beauty, harmony, variety, and pleaſure unperceived before. In every object of Nature, it beholds the great Creator of all, the Source of life and beauty, the Author of every good. Inſpired by ſcenes, in which infinite wiſdom and unbounded goodneſs are inceſſantly conſpicuous, with what rapture will the Contemplative Philoſopher, the genuine ſon of Nature, exalt his voice to heaven, in the glowing language of gratitude and adoration: "Yes! (he may exclaim) Thou Beſt of Beings! how unutterable is thy goodneſs! I behold thee in all thy wondrous works. The radiant orb of day, and, in the night, the ſilver moon, and all the ſtars, the life-infuſing ſuns of other worlds, proclaim the Great Omnipotent. In the balſamic fragrance of the flowers I

behold that incenſe riſe, which, in mingled clouds, they roll ſoft to thee, 'whoſe ſun exalts, whoſe breath perfumes, and whoſe pencil paints them'. In the delicious fruits I taſte, I perceive thy unconfined and unexhauſted bounty. Whatever pleaſures I enjoy by the kind communication of my ſenſes, ſhall recall me to thee, as the object of devout and fervent aſpiration; and thou, moſt adorable Being, who gaveſt me theſe ſenſations, wilt thus exalt and ennoble them. While I am ſtill intent in contemplating theſe material beauties, I ſoar inſenſibly to the moſt ſublime objects, to the centre of all perfection. Yes! Thou Good Supreme, thee I invoke, thee alone adore! To thee this lonely ſpot, this pleaſing ſolitude, theſe rural thoughts are ſacred, while thus I meditate on thy works, and contemplate the beauties which all reſolve in thee, thou ſource and principle of beauty and perfection".

Such are the natural effuſions of the Contemplative Philoſopher, when his eye wanders over the beauties of the Summer. And what pleaſure and ſerenity do ſuch meditations inſpire! Can any terreſtrial enjoyments be placed in competition with the manly ſources of delight which they afford? Can the wiſe and virtuous man be ever ſatiated with ſuch themes? No: were he to witneſs the revolution of a thouſand Summers, he would ſtill diſcover new objects of admiration, and new ſubjects of praiſe and adoration.

For me, when I forget the darling theme,
Whether the bloſſom blows, the Summer ray
Ruſſets the plain, inſpiring Autumn gleams,
Or Winter riſes in the blackening eaſt,
Be my tongue mute, may Fancy paint no more,
And, dead to joy, forget my heart to beat!

THOMSON.

XLII. A MORNING WALK.

The Morn, in ruſſet mantle clad,
Walks o'er the dew of yon high eaſtern hill.
——The jocund Day
Stands tiptoe on the miſty mountains tops.

SHAKSPEARE.

Sweet is the breath of Morn, her riſing ſweet,
With charm of earlieſt birds; pleaſant the Sun,
When firſt on this delightful land he ſpreads
His orient beams on herb, tree, fruit, and flower,
Gliſt'ring with dew. MILTON.

WHAT a magnificent phenomenon is every day exhibited in the riſing of the ſun! yet how common is the obſervation, that indolence and the love of ſleep prevent a great part of mankind from contemplating this beauteous wonder of the creation! What numbers are there, in high life eſpecially, who prefer a few more hours of ſleep to all the pleaſures of a morning walk!

This circumſtance has been ridiculed with great propriety by one of my predeceſſors: "This unaccountable diſpoſition in mankind, to continue awake in the night, and ſleep in the ſunſhine, has made me inquire, whether the ſame change has happened to any other animals? For this reaſon, I deſired a friend of mine in the country to let me know, whether the lark riſes as early as it did formerly, and whether the cock begins to crow at his uſual hour? My friend has anſwered me, That his poultry are as regular as ever, and that all the birds and the beaſts of his neighbourhood keep the ſame hours, that they have obſerved in the memory of man; and the ſame which, in all probability, they have kept for theſe five thouſand years". The ſame excellent au-

thor continues, in a more ſerious ſtrain, "Who would not wonder at this perverted reliſh of thoſe who are reckoned the moſt polite part of mankind, that prefer co l and candles to the Sun, and exchange ſo many cheerful morning hours, for the pleaſures of midnight revels and debauches? If a man were only to conſult his health, he would chooſe to live his whole time, if poſſible, in daylight; and to retire out of the world into ſilence and ſleep, while the raw damps and unwholeſome vapours flie abroad, without a ſun to diſperſe, moderate, or control them. For my own part, I value an hour in the morning as much as common libertines do an hour at midnight. When I find myſelf awakened into being, and perceive my life renewed within me, and, at the ſame time, ſee the whole face of Nature recovered out of the dark uncomfortable ſtate in which it lay for ſeveral hours, my heart overflows with ſuch ſecret ſentiments of joy and gratitude, as are a kind of implicit praiſe to the great Author of Nature. The mind, in theſe early ſeaſons of the day, is ſo refreſhed in all its faculties, and born up with ſuch new ſupplies of animal ſpirits, that ſhe finds herſelf in a ſtate of youth, eſpecially when ſhe is entertained with the breath of flowers, the melody of birds, the dews that hang upon the plants, and all thoſe other ſweets of Nature that are peculiar to the morning.—But it is impoſſible for a man to have this reliſh of being, this exquiſite taſte of life, who does not come into the world before it is in all its noiſe and hurry; who loſes the riſing of the ſun, the ſtill hour of the day, and immediately upon his firſt getting up plunges himſelf into the ordinary cares or follies of the world".

And ſuch are the ſentiments of the poet of the Seaſons, whoſe ſoul was ſo capable of enjoying, and his genius of deſcribing, the pleaſures of the Morning:

Falſly luxurious, will not man awake;
And, ſpringing from the bed of ſloth, enjoy
The cool, the fragrant, and the ſilent hour,
To meditation due and ſacred ſong?
For is there aught in ſleep can charm the wiſe?
To lie in dead oblivion, loſing half
The fleeting moments of too ſhort a life;
Total extinction of th' enlighten'd ſoul!
Or elſe to feveriſh vanity alive,
Wilder'd, and toſſing through diſtemper'd dreams?
Who would in ſuch a gloomy ſtate remain
Longer than Nature craves? when every muſe
And every blooming pleaſure wait without,
To bleſs the wildly-devious morning walk?

But it is not indolence and the love of ſleep only, that give riſe to theſe obſervations. Beauty ceaſes to charm, and magnificence to ſtrike, when the object, however perfect it may be, is become familiar to a mind, unaccuſtomed to reflect on the order and harmony of the creation, and on thoſe wonderful relations between all the objects of it, which naturally lead the devout man to the contemplation of a Firſt Cauſe, the Life, and Soul, and Energy of All. Hence we obſerve a kind of culpable inattention and indifference, even in thoſe who are moſt habituated to rural ſcenes, and who, conſequently, muſt enjoy the moſt frequent opportunities of admiring and contemplating the works of Nature. Satisfied, for inſtance, that the ſun enlightens the world, and diſpenſes the moſt eſſential benefits to mankind, they have no ſolicitude, however, to explore the cauſe of theſe wonderful effects. They view, every day, the moſt glorious object in Nature, without one emotion of grateful pleaſure, without one idea or reflection.

In Paradiſe Loſt, when Adam awakes Eve in the morning, he reminds her of the ſweet pleaſures ſhe is loſing:

Awake,
My faireſt, my eſpous'd, my lately found,
Heaven's laſt beſt gift, my ever new delight,
Awake; the morning ſhines, and the freſh field
Calls us: we loſe the prime, to mark how ſpring
The tender plants, how blows the citron grove,
What drops the myrrh, and what the balmy reed,
How Nature paints her colours, how the bee
Sits on the bloom extracting liquid ſweet.

Milton, in theſe inexpreſſibly charming lines, had his eye, no doubt, on a paſſage in the Song of Solomon: "Come, my beloved, let us go forth into the field: let us lodge in the villages: let us get up early to the vineyards: let us ſee if the vine flouriſh, whether the tender grape appear, and the pomegranates bud forth".

It is certain, that we nowhere meet with a more glorious or more pleaſing ſhow of Nature, than what appears in the heavens at the riſing of the ſun. The richeſt decorations, the moſt variegated and the moſt gorgeous ſcenery, that human fancy can imagine, muſt vaniſh into nothing, when compared with a ſpectacle, in which radiance and beauty are ſo preeminent. The firſt aſpect of the morning is pale and white, or gray. Hence Milton ſtyles her Leucothea, which, in the Greek Language, ſignifies the White Goddeſs:

To reſalute the world with ſacred light
Leucothea wak'd, and with freſh dews imbalm'd
The earth.

Leucothea, whom the Romans called Matuta, is the harbinger of Aurora; and the horizon, with the nearer approach of the ſunbeams, now aſſumes a roſeate hue. Thus Lucretius:

Roſeam Matuta per oras
Ætheris Auroram defert, et lumina pandit.

O'er all the ſkies Matuta ſpreads her light,
And brings the Morn in roſeate colours bright.

And thus Homer gives roſy fingers to the Morn [a], and Milton roſy ſteps [b] and a roſy hand [c].

The Morning, in fine, diſplays to the world a new and magnificent creation. The ſhades of night had concealed the view and enjoyment of earth and ſkies. But now the light returns, and we behold all Nature renewed in youth and beauty. We are reminded of Milton's fine deſcription of the creation, when God firſt commanded the earth to "put forth the verdant graſs":

He ſcarce had ſaid, when the bare earth, till then
Deſert and bare, unſightly, unadorned,
Brought forth the tender graſs, whoſe verdure clad
Her univerſal face with pleaſant green;
Then herbs of every leaf, that ſudden flower'd,
Opening their various colours, and made gay
Her boſom ſmelling ſweet.——
——With high woods the hills were crown'd,
With tufts the vallies, and each fountain ſide
With borders 'long the rivers; that earth now
Seem'd like to heaven, a ſeat where gods might dwell,
Or wander with delight, and love to haunt
Her ſacred ſhades.

Nor is this poetic fiction: the morning landſcape is indeed exquiſitely beautiful. We behold the mountains crowned, as if by the inſtantaneous effect of enchantment, with majeſtic woods; the ſpreading lawns covered with herds and flocks; the fields ripening into harveſt; and the meadows enamelled

[a] Now did the roſy-finger'd Morn ariſe,
And ſhed her ſacred light along the ſkies.

[b] Now Morn her roſy ſteps in the eaſtern clime
Advancing, ſow'd the earth with orient pearl.

[c] ——Morn,
Wak'd by the circling Hours, with roſy hand,
Unbarr'd the gates of light.

with flowers, and watered by meandering ſtreams. The whole horizon looks gay: the ſcattered clouds aſſume a vivid variety of hues; the light vapours are converted into gold; and every plant and every flower ſparkles with orient pearl. In proportion as the light increaſes, the ſpectacle is ſtill more beautiful. By ſoft progreſſions of light, Nature at length appears in her utmoſt perfection. The ſun is riſing. A firſt ray eſcaped from the mountain's top, that ſtill conceals the radiant orb from the ſight, darts rapidly from one end of the horizon to the other. Succeſſive rays ſtrengthen the firſt. The face of the ſun is diſengaged by degrees, till it looks, at laſt, in boundleſs majeſty abroad! All Nature rejoices in a delightful renovation of life and vigour. The feathered tribes ſalute the bright ſource of day with their melodious notes. In a word, every living creature is in action, and is ſenſible to new returns of pleaſure and new capacities of enjoyment.

Mallet has amplified this pleaſing ſubject with the moſt beautiful and pictureſque imagery:

And now pale glimmering on the verge of heaven,
From eaſt to north in doubtful twilight ſeen,
A whitening luſtre ſhoots its tender beam;
While ſhade and ſilence yet involve the ball.
Now ſacred Morn, aſcending, ſmiles ſerene
A dewy radiance, brightening o'er the world.
Gay daughter of the Air, for ever young,
For ever pleaſing! Lo, ſhe onward comes,
In fluid gold and azure looſe array'd,
Sun tinctur'd, changeful hues. At her approach,
The weſtern gray of yonder breaking clouds
Slow-reddens into flame: the riſing miſts,
From off the mountain's brow, roll blue away
In curling ſpires, and open all his woods,
High-waving in the ſky: th' uncolour'd ſtream,
Beneath her glowing ray, tranſlucent ſhines.
Glad Nature feels her thro' her boundleſs realms
Of life and ſenſe; and calls forth all her ſweets,

Fragrance, and ſong. From each unfolding flower
Tranſpires the balm of life, that Zephyr wafts,
Delicious, on his roſy-wing: each bird,
Or high in air, or ſecret in the ſhade,
Rejoicing, warbles wild his matin hymn.
While beaſts of chaſe, by ſecret inſtinct mov'd,
Scud o'er the lawns, and, plunging into might,
In brake, or cavern, ſlumber out the day.
Invited by the cheerful Morn abroad,
See, from his humble roof, the good man comes
To taſte her freſhneſs, and improve her riſe
In holy muſing. Rapture in his eye,
And kneeling wonder, ſpeaks his ſilent ſoul,
With gratitude o'erflowing, and with praiſe!
Now induſtry is up. The village pours
Her uſeful ſons abroad to various toil:
The labourer here, with every inſtrument
Of future plenty arm'd; and there the ſwain,
A rural king amid his ſubject-flocks,
Whoſe bleatings wake the vocal hills afar.
The traveller, too, purſues his early road,
Among the dews of Morn. Aurora calls:
And all the living landſcape moves around.
But ſee, the fluſh'd horizon flames intenſe
With vivid red, in rich profuſion ſtream'd
O'er heaven's pure arch. At once the clouds aſſume
Their gayeſt liveries; theſe with ſilvery beams
Fring'd lovely; ſplendid thoſe in liquid gold:
And ſpeak their ſovereign's ſtate. He comes, behold!
Fountain of light and colour, warmth and life!
The king of glory! Round his head divine,
Diffuſive ſhowers of radiance circling flow,
As o'er the Indian wave up riſing fair
He looks abroad on Nature, and inveſts,
Where'er his univerſal eye ſurveys,
Her ample boſom, earth, air, ſea, and ſky,
In one bright robe, with heavenly tinctures gay.

The limits of this paper will not permit me to make any reflections on two beautiful phenomenons of a morning proſpect, which have afforded the poets the happieſt ſubjects of deſcription: I mean

the Dews and *the Sun*. Of the firſt I have already amply treated in a former paper; and the latter ſhall be the ſubject of a future one. At preſent, I ſhall be content to imagine the Contemplative Philoſopher in his morning walk, enraptured with the beautiful face of Nature, and thus pouring forth the devout effuſions of his heart: "Adorable Being! In the glories of the morning I behold thy infinite wiſdom and power. With the ſoaring lark, whoſe ſweet ſong proclaims the approach of day, I aſpire to thee, O God, the Father of the Creation. The cheerfulneſs and joy that inſpires all Nature, and this univerſal renovation of life and beauty, invite me alſo to raiſe my heart to thee, with the moſt lively tranſports of gratitude and joy. At this inſtant, that the ſun darts its earlieſt rays upon the earth, what millions of thy creatures are adoring and praiſing thee! How then can I be inſenſible and ſilent at this view of univerſal beauty and univerſal goodneſs? From thee ſprings the ſplendour of the morning, from thee, the great fountain of light and life. Thou alone haſt ſpread the horizon with theſe beauteous tints, and given pervading power and energy to that ſun. The verdant earth, the ſmiling landſcape around, is decorated by thy hand. The grateful emotions, which the glorious ſcene inſpires, ſpring too from thee. Thou haſt endued me with underſtanding, with that celeſtial faculty, which thus enables me to diſcover thee in thy wondrous works. Continue, Beſt of Beings, to protect and guide me. Let me not be content with theſe morning aſpirations. Beautiful as this ſolitude is, and charming as theſe reflections are, let me now return to ſocial life and to active goodneſs. Ever grateful to thee, and kind to my fellow-creatures, may a life of uniform piety aud virtue be accepted by thee as the nobleſt hymn of praiſe and adoration".

XLIII. ON THE SUN.

Alme Sol, curru nitido diem qui
Promis et celas, aliusque et idem
Nasceris——— HORACE.

Fair Sun, who with unchanging beam
Rising another and the same,
Dost from thy beamy car unfold
The glorious day,
Or hide it in thy setting ray—— FRANCIS.

Great source of day! best image here below
Of thy Creator, ever pouring wide,
From world to world, the vital ocean round,
On Nature write with every beam His praise.
THOMSON.

THE Sun has been justly styled the soul of the universe, as it not only produces all the necessaries of life, but has a particular influence in cheering the mind of man. He can never be satiated then, one would think, with the glorious scenes which the eye discovers, when this radiant orb sheds its lustre abroad; nor can imagination ever cease to contemplate, with pleasure, its wonderful use and essential importance in the creation.

In my preceding paper, I considered the rising of the sun as forming one of the most beautiful appearances in a morning prospect. How striking the scene when we first observe the fiery rays which the Sun scatters among the clouds, as harbingers of his approach. As the illumination increases, the earth seems all in a glow, and we expect the glorious orb, long before he discovers himself above the horizon. We imagine, every moment, that we see him. At length he appears. His rays dart, like lightning,

over the face of Nature, and darkneſs vaniſhes at the ſight. Man glories in his habitation, and beholds it embelliſhed with renovated beauty. The lawn is refreſhed by the coolneſs of the night, and the light of the morning diſplays its increaſing verdure. The dew-beſpangled flowers, that enamel its ſurface, glitter in the ſunbeams, and, like rubies and emeralds, dart their colours on the eye. The cheerful birds unite in choirs, and hail, in concert, the parent of life. At this enchanting moment, not one is ſilent. All Nature is enlivened by his preſence, and gladdened by his gifts. Millions of glittering inſects awake into exiſtence, and flutter in his rays. The bleating flocks, and lowing herds, ſalute the welcome bleſſing. The hills, the valleys, and the woods, reſound with rural harmony. All that is vocal unites in the general choir; and all that has breath exults in the enlivening influence. In man, in particular, the aſſemblage of ſo many pleaſing objects imparts a glowing ſenſation, that ſeems to penetrate the ſoul. Who, indeed, can withſtand the rapture of this ſhort interval of enchantment? Who can behold with indifference a ſcene, at once ſo magnificent, ſo beautiful, and ſo delightful?—But I am aware that, in my morning walk, I have already expatiated on this ſcene; a ſcene, however, productive of a pleaſure that will ever bear repetition, and of a variety that never can be exhauſted.

The Sun, that radiant orb, with which, as a part of the planetary ſyſtem [a] to which our globe belongs, we are ſo intimately connected, is defined, with reſpect to us, to be that great luminary which enlightens the world, and whoſe preſence conſtitutes the day. In the infancy of aſtronomy it was reckoned among the planets; but it is now numbered among the fixed ſtars. It appears bright and large

[a] See No. VII, Reflections on the Solar Syſtem.

in comparison with them; because we keep constantly near the Sun, and are at an immense distance from the stars: for a spectator, placed as near to any star as we are to the Sun, would see that star a body as large and bright as the Sun appears to us; and a spectator, as far distant from the Sun as we are from the stars, would see the Sun as small as we see a star, divested of all its circumvolving planets; and, in numbering the stars, he would reckon it among them.

The figure of the Sun is a spheroid, higher under the equator than about the poles. His diameter is computed to be 763,000 miles. His solid bulk is 64 million of times as big as that of the Moon, and a million of times bigger than that of the Earth. His distance from the Earth, in round numbers, is about 95 millions of miles; a distance so prodigious, that a cannon-ball, which moves at the rate of about eight miles in a minute, would be something more than twenty-two years in going from the Earth to the Sun. This account of the diameter, magnitude, and distance of the Sun, is deduced from the determinations of the most eminent astronomers in Europe, who were sent out to the most convenient parts of the Earth, for the purpose of observing the transits of Venus over the Sun, in the years 1761 and 1769.

The Sun was generally considered by the ancients as a globe of pure fire; but, from a number of maculæ, or dark spots, which, by means of a telescope, may be seen on different parts of his surface, it appears that this opinion was ill-founded. The spots consist, in general, of a nucleus, or central part, which appears much darker than the rest, and seems to be surrounded by a mist or smoke; and they are so changeable in their situation and figure, as frequently to vary during the time of observation. Some of the largest of them, which are found to ex-

ceed the bulk of the whole earth, are often to be ſeen for three months together; and, when they diſappear, they have been ſuppoſed to be converted into faculæ, or luminous ſpots, which appear much brighter than the reſt of the Sun[a]. About the time that the ſolar ſpots were firſt diſcovered by Galileo, forty or fifty of them might be frequently ſeen on the Sun at a time; but, at preſent, we can ſeldom obſerve more than thirty; and there have been periods of ſeven or eight years in which none could be ſeen.

Various have been the opinions concerning the nature, origin, and ſituation of the ſolar ſpots. It has been imagined, that the maculæ are occaſioned by ſmoke and opaque matter thrown out by volcanos or burning mountains of immenſe magnitude; and that when the eruption is nearly ended, and the ſmoke diſſipated, the fierce flames are expoſed, and appear like faculæ or luminous ſpots. M. de la Hire imagined the Sun to be in a continual ſtate of fuſion, and that the ſpots which we obſerve, are only the eminences of large maſſes of opaque matter, which, by the irregular agitations of the fluid, ſome-

[a] But this converſion of the maculæ, or dark ſpots, into the faculæ, or luminous ones, has been denied. Hevelius, indeed, ſupports the opinion; but Huygens declares, that he was never able to diſcover any faculæ; and that all the foundation that he could ſee for the notion was, that in the darkiſh clouds that frequently ſurround the maculæ, little points, or ſparks, brighter than the reſt, are ſometimes diſcerned. Many authors, after Kircher and Scheiner, have generally repreſented the Sun's body full of bright, fiery ſpots, which they conceive to be a ſort of volcanos in the body of the Sun; but Huygens, and others of the lateſt and beſt authority, finding that the beſt teleſcopes diſcover nothing of the matter, agree to explode the notion of faculæ. The cauſe of what have been ſuppoſed to be ſuch they attribute to the tremulous agitation of the vapours near our earth; the ſame as ſometimes ſhows a little unevenneſs in the circumference of the Sun's diſk, when viewed through a teleſcope. Strictly, then, the faculæ are not eructations of fire and flame, but refractions of the Sun's rays in the rarer exhalations, which, being condenſed in the neighbourhood of that ſhade, ſeem to exhibit a light greater than that of the Sun.

times ſwim upon the ſurface, and ſometimes ſink and diſappear. Others have ſuppoſed them to be occaſioned by a number of planets circulating round the Sun, at a ſmall diſtance from his ſurface. But Dr. Alexander Wilſon, by attending particularly to the different phaſes preſented by the umbra, or ſhady zone, of a ſpot of an extraordinary ſize, that appeared upon the Sun in November 1769, during its progreſs over the ſolar diſk, was led to form a new and ſingular conjecture concerning the nature of theſe appearances: which he ſeems afterward to have confirmed and eſtabliſhed by repeated obſervations. The reſults of theſe obſervations are, that the ſolar maculæ are cavities in the body of the Sun; that the nucleus, as the middle or dark part has been uſually called, is the bottom of the excavation; and that the umbra, or ſhady zone, uſually ſurrounding it, is the ſhelving ſides of the cavity. Dr. Wilſon appears not only to have aſcertained the reality of theſe immenſe excavations in the body of the Sun, but to have pointed out a method of meaſuring the depth of them. He eſtimates, in particular, that the nucleus, or bottom of the large ſpot abovementioned, was not leſs than a ſemi-diameter of the earth, or about 4000 miles below the level of the Sun's ſurface; while its other dimenſions were of a much larger extent. From his obſervations it may be further inferred, that the body of the Sun, in the depth of the nucleus, either emits no light, or emits ſo little as to appear dark, when ſeen at the ſame time, and compared with that reſplendent, and probably, in ſome degree, fluid ſubſtance which covers his ſurface. This manner of conſidering theſe phenomenons naturally gives riſe to many curious ſpeculations and inquiries. It is natural to inquire, for inſtance, by what great commotions this refulgent matter is thrown up on all ſides, ſo as to expoſe to our view the darker part of the Sun's

body, which was before covered by it? What is the nature of this ſhining matter? And why, when the excavation is formed in it, is the luſtre of this ſhining ſubſtance, which forms the ſhelving ſides of the cavity, ſo far diminiſhed, as to give the whole the appearance of a ſhady zone, or darkiſh atmoſphere, ſurrounding the denuded part of the Sun's body? But for a more ample detail of Dr. Wilſon's obſervations on the whole ſubject, I muſt refer my readers to the Philoſophical Tranſactions, vol. lxiv.

The motion of the maculæ is from eaſt to weſt, and as they are obſerved to move quicker when they are near the central regions, than when they are near the limb, it follows that the Sun muſt be a ſpherical body, and that he revolves on his axis. The time in which he performs this revolution, as obſerved by Caſſini, is 25 days, 14 hours, and 8 minutes.

Beſide the ſolar ſpots, the zodiacal light is a ſingular phenomenon which accompanies the Sun, and is uſually attributed to his atmoſphere. It begins to appear a little before ſunriſe, and ſeems at firſt like a faint, whitiſh zone of light, reſembling the milky way, with its borders ill-terminated, and ſcarcely to be diſtinguiſhed from the twilight, which is ſeen commencing near the horizon. It is then but little elevated, and its figure nearly agrees with that of a flat lenticular ſpheroid, ſeen in profile. As it riſes above the horizon, it becomes brighter and larger to a certain point, after which the approach of day renders it gradually leſs apparent, till it becomes quite inviſible.

From this philoſophical account of the Sun, and the principal phenomenons which he exhibits, the next and moſt obvious inquiry is into his pervading energy and eſſential importance in the creation, and particularly to our globe. But nothing can equal what Thomſon has ſaid upon this ſubject, in his

beautiful Hymn to the Sun. I refer my readers, therefore, to this, not only as a poetical illuſtration, but as the nobleſt account that has ever been given, of the dignity, uſe, and beauty of this reſplendent orb.

XLIV. ON THE NATURE OF LIGHT.

Faireſt of beings! firſt created light!
Prime cauſe of beauty! for from thee alone,
The ſparkling gem, the vegetable race,
The nobler worlds that live and breathe, their charms,
The lovely hues peculiar to each tribe,
From thy unfading ſource of ſplendour draw!
In thy pure ſhine, with tranſport I ſurvey
This firmament, and thoſe her rolling worlds,
Their magnitudes and motions. MALLET.

WE experience, every moment, the utility of that light which inveſts our globe; but there is not a ſubject, concerning the nature of which ſuch a variety of opinions have been formed. Light is defined to be that ſenſation occaſioned in the mind by the view of luminous bodies; or, that property in bodies, whereby they are fitted to excite thoſe ſenſations in us. The Greeks conſidered light as an accident, or property, reſulting from the firſt principles of things; and Des Cartes defines it to be a globulous matter, diffuſed through the univerſe; which being impelled by the ſun, ſtrikes upon our eyes, in the ſame manner as a ſtaff, that is puſhed at one end, preſſes in the ſame inſtant at the other. But Des Cartes, and the ancient philoſophers, in particular, ſpoke the language of hypotheſis and conjecture: our immortal Newton had

recourſe to experiment and obſervation. The rays of light, according to him, are ſmall corpuſcles, or particles of matter, emitted with exceeding celerity from the luminous body; with a velocity ſo immenſe, indeed, as to enable them to move at the inconceivable rate of 11,000,000 miles in a minute. Mr. Roemer, a Daniſh philoſopher, was the firſt who ſhowed, that light is about eight minutes in its paſſage from the ſun to the earth. This idea was firſt ſuggeſted to him, by obſerving the eclipſes of Jupiter's moons, by which it appeared, to a demonſtration, that the motion of light is not inſtantaneous, but progreſſive, or ſuch as would carry it through a ſpace equal to the radius, or ſemi-diameter of the earth's annual orbit in about eight minutes of time: ſo that if the ſun were annihilated, we ſhould ſee him for eight minutes afterward, and if he were created again, it would be eight minutes before we ſhould ſee him. The minuteſt particles, which are thrown off from the body of the ſun, move through a ſpace of 95,000,000 miles in eight minutes, which is about a million of times ſwifter than the motion of a cannon-ball, when it is firſt projected from the mouth of the piece: a rapidity too great for the imagination to follow, or the mind to comprehend.

The wonderful diviſibility of the parts of matter is no where more apparent, than in the minuteneſs of the particles of light. Dr. Nieuwentyt has computed, that an inch of candle, when converted into light, becomes divided into 269,617,040 parts, with 40 ciphers annexed; at which rate there muſt iſſue out of it, when burning, 418,660 particles, with 39 ciphers more, in the ſecond of a minute; which is vaſtly more than a thouſand times a thouſand million times the number of ſands the whole earth can contain; reckoning ten inches to one foot, and that 100 ſands are equal to one foot.

It muſt be acknowledged, that many difficulties and objections have been urged againſt the materiality of light, or the hypotheſis of light, conſiſting of ſmall particles emitted from luminous bodies; and that many eminent philoſophers, both foreigners and Engliſh, have recurred to the opinion, that light conſiſts of vibrations propagated from the luminous body, through a ſubtile etherial medium. Among theſe are the names of Euler and Franklin, whoſe arguments have been combated by Dr. Horſley, Mr. Melville, and others. But an account of their reaſonings on this ſubject, would neceſſarily lead me into a diſquiſition much too abſtruſe for the popular and intelligible manner in which I wiſh to conduct this paper. Sir Richard Blackmore, in his beautiful philoſophical poem on the Creation, thus alludes to the difficulties which attend the ſubject:

Behold the light emitted from the ſun!
What more familiar, and what more unknown?
While by its ſpreading radiance it reveals
All Nature's face, it ſtill itſelf conceals.
See how each morn it does its beams diſplay,
And on its golden wings bring back the day!
How ſoon th'effulgent emanations fly
Through the blue gulf of interpoſing ſky!
How ſoon their luſtre all the region fills,
Smiles on the vallies, and adorns the hills!
Millions of miles, ſo rapid is their race,
To cheer the earth, they in few moments paſs.
Amazing progreſs! At its utmoſt ſtretch,
What human mind can this ſwift motion reach?
But if, to ſave ſo ſwift a flight, you ſay,
The ever rolling orb's impulſive ray
On the next threads and filaments does bear,
Which form the ſpringy texture of the air;
That thoſe ſtill ſtrike the next, till to the ſight
The quick vibration propagates the light;
'Tis ſtill as hard, if we this ſcheme believe,
The cauſe of light's ſwift progreſs to conceive.

That light, however, is a real ſubſtance, notwithſtanding the objections that have been urged againſt this hypotheſis, ſeems to be eſtabliſhed by the phenomenons of the Bolognian ſtone, and of other ſubſtances, which poſſeſs the remarkable property of imbibing light, of retaining it for ſome time, and afterward of emitting it[a].

The doctrine of the materiality of light is further confirmed by thoſe experiments, which demonſtrate, that the colour and inward texture of ſome bodies are changed, in conſequence of their being expoſed to the light. Among various obſervations of this kind, was that made by M. Duhamel, who found that the juice of a certain ſhellfiſh in Provence contracted a fine purple colour when expoſed to the light of the ſun, and that the ſtronger the light, the more ſplendid was the colour. Pieces of cloth, dipped in this liquor, and expoſed to the ſun, became red, although they were incloſed in glaſs; but they acquired none of this colour in the ſame expoſure, if they were covered with the thinneſt plates of metal.

The expanſion or extenſion of any portion of light is inconceivable. Dr. Hook ſhows, that it is as unlimited as the univerſe; proving it from the immenſe diſtance of ſome of the fixed ſtars, the light of which becomes ſenſible to the eye, by means of a teleſcope. He adds, that they are not the great bodies only of the ſun or ſtars that are thus liable to diſ-

[a] The Bolognian, or Bononian ſtone, is a ſmall, gray, ſoft, gloſſy, fibrous, ponderous, ſulphureous ſtone, about the bigneſs of a large walnut. When broken, it has a kind of cryſtal, or a ſparry talc within. It is found about Bologna, or Bononia, in Italy, and, when duly prepared, makes a ſpecies of phoſphorus.—The diſcovery was made in 1630, by Vincenzo Caſciarolo, a chymiſt, who, having found ſome pieces in a river, carried them home, in hopes, by the fire, to extract ſilver from them; but, inſtead of what he expected, he found that admirable phenomenon they exhibit, which conſiſts in this, that being expoſed to the light they retain it, and ſhine for the ſpace of ſix or eight hours in the dark.

perſe their light through the vaſt expanſe of the univerſe, but the ſmalleſt ſpark of a lucid body muſt do the ſame, even the ſmalleſt globule ſtruck from a ſteel by a flint.

Sir Iſaac Newton obſerves, that bodies and light act mutually upon each other; bodies on light, in emitting, reflecting, refracting, and inflecting it; and light on bodies, by heating them, and putting their parts into a vibrating motion, in which heat principally conſiſts. For all fixed bodies, he obſerves, when heated beyond a certain degree, emit light, and ſhine; which ſhining, &c. appears to be owing to the vibrating motions of their parts; and all bodies, abounding in earthly and ſulphureous particles, if ſufficiently agitated, emit light, which way ſoever that agitation be effected. Thus, ſea-water ſhines in a ſtorm; quickſilver, when ſhaken in vacuo; cats, or horſes, when rubbed in the dark; and wood, fiſh, and fleſh when putrefying.

Light proceeding from putreſcent animal and vegetable ſubſtances, as well as from glowworms, is mentioned by Ariſtotle. Bartholin mentions four kinds of luminous inſects, two with wings, and two without; but it is aſſerted by travellers, that in hot climates, they are found in much greater numbers, and of different ſpecies. In particular, on the river Menam, which runs through Siam, a vaſt number of thoſe inſects, called fire-flies, make a beautiful appearance in the night:

On Menam's orient ſtream, that nightly ſhines
With inſect-lamps. THOMSON.

There is one property of light, called *refraction*, which I will mention here, becauſe it is capable of a very eaſy and familiar illuſtration, and will account for a very common, but ſeemingly extraordinary phenomenon. When a ray of light paſſes out of one medium into another, it is refracted, or turned

out of its firſt courſe, according as it falls more or leſs obliquely on the refracting ſurface which divides the two mediums. Any perſon may exemplify this by the following experiment: put a ſhilling in an empty baſin, and retire to ſuch a diſtance, that the edge of the baſin ſhall juſt hide it from your ſight; then keeping yourſelf ſteady, let another perſon fill the veſſel gently with water; and, as the water riſes toward the top, the ſhilling will become more and more viſible, till, at length, the whole of it will be diſtinctly ſeen, appearing as if it had been raiſed above the bottom of the baſin.

This proves, that the rays of light are refracted, or bent downward, in their paſſage out of the water into the air; and as they now come to the eye in a more oblique direction, the object muſt neceſſarily appear to be elevated, and in a different ſituation from that in which it was really placed. The ſame thing may alſo be ſhown thus: place the baſin in ſuch a manner, that the ſun may ſhine obliquely on it, and obſerve where the ſhadow of the rim falls upon the bottom; then fill it with water, and the ſhadow will not extend ſo far as it did when the veſſel was empty; which ſhows that the rays have changed their direction, by paſſing out of one medium into another of a different denſity.

The leſs obliquely the rays fall, the leſs they will be refracted; and if they fall perpendicularly, they will not be refracted at all. For, in the laſt experiment, the higher the ſun riſes, the leſs will be the difference between the places, where the edge of the ſhadow falls, in the empty and full baſin. And if a ſtick be laid acroſs the baſin, and the ſun's rays be reflected perpendicularly into it from a looking-glaſs, the ſhadow of the ſtick will fall upon the ſame part of the bottom, whether the baſin be full or empty. The ſame effects will alſo take place, when the experiment is performed with any other fluid:

but the denſer the medium, the more will light be refracted in paſſing through it.

From theſe obſervations it will readily appear, that objects can ſeldom be ſeen in their true places. We are deceived by every thing around us: the ſight is no leſs ſubject to error than the reſt of our ſenſes: they all contribute to our pleaſure, and promote our happineſs by various means. In conſequence of this property of refraction, we enjoy the ſight of the ſun when he is really below the horizon, for a little time before his riſing and for a little time after his ſetting. This is alſo the cauſe which produces the crepuſculum, or morning and evening twilight: for the rays of the ſun, in falling upon the higher part of the atmoſphere, are reflected back to our eyes, and form a faint light, which gradually augments till it becomes day. It is in thoſe brilliant colours which paint the clouds, before the riſing of the ſun, that the poets have placed Aurora, or the goddeſs of the morn: ſhe opens the gates of day with her roſy fingers; and the daughter of the Air and of the Sun has her throne in the atmoſphere.

Had no ſuch atmoſphere exiſted, the rays of light would have come to us in ſtraight lines, and the appearance and diſappearance of the ſun would have been inſtantaneous; we ſhould have had a ſudden tranſition from the brighteſt ſunſhine to the moſt profound darkneſs, and from thick darkneſs to a blaze of light. Refraction, therefore, is extremely uſeful, not only as it prepares us gradually for the light of the ſun, but as it occaſions twilight, and thus prolongs the duration of the day. Nature has eſtabliſhed theſe gradations, to heighten our pleaſures by variety: the ſcene is perpetually changing, but the order of things is immutable.

With what exalted ſentiments of devotion ought the Contemplative Philoſopher to conſider the various and unſpeakably beautiful phenomenons of

light! We find it to be little leſs than the life and pleaſure of all animated beings. Of what benefit, indeed, could life be; what pleaſure, what comfort could we enjoy, in the horrors of perpetual darkneſs? How could we provide ourſelves with food, and the other neceſſaries of life? How could we tranſact the leaſt buſineſs? How could we correſpond with each other, or be of the leaſt reciprocal ſervice, without light, and thoſe admirable organs of the body, which the Omnipotent Creator has adapted to the perception of this ineſtimable benefit?

But it is unneceſſary to enumerate the inexpreſſible advantages of a bleſſing, of which the moſt inattentive of mankind muſt be ſenſible. What is applied to Wiſdom, in the book called *The Wiſdom of Solomon*, "She is a pure influence flowing from the glory of the Almighty—ſhe is the brightneſs of the everlaſting Light", has been applied by Milton to Light, with the moſt beautiful propriety:

Bright effluence of bright eſſence increate.

In a word, when we conſider the wonderful beauty and pleaſures of which light is the eſſential ſource, with how much is ſtill involved in myſtery, notwithſtanding the moſt diligent inquiries into its nature and properties, by the moſt illuſtrious philoſophers, well may we exclaim in the beautiful language of Thomſon:

How then ſhall I attempt to ſing of Him
Who, Light Himſelf, in uncreated light
Inveſted deep, dwells awfully retir'd
From mortal eye, or angel's purer ken;
Whoſe ſingle ſmile has, from the firſt of time,
Fill'd, overflowing, all yon lamps of heaven,
That beam for ever through the boundleſs ſky:
But, ſhould He hide his face, th' aſtoniſh'd ſun,
And all th' extinguiſh'd ſtars, would looſening reel
Wide from their ſpheres, and Chaos come again.

XLV. ON COLOURS.

Colours are but the phantoms of the day,
With that they 're born, with that they fade away;
Like beauty's charms, they but amuse the sight,
Dark in themselves, till by reflection bright;
With the sun's aid to rival him they boast,
But light withdrawn, in their own shades are lost.

HUGHES.

THE inquiry, in my former paper, into the nature and properties of light, leads me to consider next the admirable relations which the Deity has established between light itself and the surfaces of different bodies, whence proceed the various phenomenons of colours.

Different are the opinions of ancient and modern authors, and of the several sects of philosophers, with regard to the nature and origin of the phenomenon Colour. The most popular opinion was long that of Aristotle, who maintained colour to be a property residing in the coloured body, and to exist independantly of light. But to this doctrine it was objected, that the neck and feathers of a pigeon or a peacock, change their colours, according to their positions. Thus Lucretius:

Pluma columbarum quo pacto in sole videtur, &c.

LIB. II. 800—806.

The plumes that go around the pigeon's head
Sometimes look brisker with a deeper red;
And then, in different positions seen,
Show a gay sky, all intermix'd with green:
And so in peacocks tails, all fill'd with light,
The colour varies with the change of site. CREECH.

It is now universally admitted, that colour is a property inherent in light, whereby, according to

the different ſizes and magnitudes of its parts, it excites different vibrations in the fibres of the optic nerve; which, propagated to the ſenſorium, affect the mind with different ſenſations. Or colour may be defined a ſenſation of the ſoul, excited by the application of light to the retina of the eye; and different, as that light differs in the degree of its refrangibility, and the magnitude of its component parts.

The philoſophy of colours is not unnoticed by the poets: Cowley, in particular, thus addreſſes Light, in a beautiful hymn:

All the world's bravery, that delights our eyes,
Is but thy ſeveral liveries:
Thou the rich die on them beſtow'ſt,
Thy nimble pencil paint'ſt the landſcape as thou go'ſt.

A crimſon garment in the roſe thou wear'ſt;
A crown of ſtudded gold thou bear'ſt;
The virgin lilies, in their white,
Are clad but with the lawn of almoſt naked light.

The violet, Spring's little infant, ſtands
Girt in thy purple ſwaddling-bands:
On the fair tulip thou doſt doat;
Thou cloth'ſt it in a gay and party-colour'd coat.

With flame condens'd thou doſt thy jewels fix,
And ſolid colours in it mix;
Flora herſelf envies to ſee
Flowers fairer than her own, and durable as ſhe.

Thus Thomſon in his deſcription of the rainbow:

Refracted from yon eaſtern cloud,
Beſtriding earth, the grand ethereal bow
Shoots up immenſe; and every hue unfolds,
In fair proportion running from the red,
To where the vi'let fades into the ſky.
Here awful Newton, the diſſolving clouds
Form, fronting on the ſun, thy ſhowery priſm;

And to the ſage-inſtructed eye unfold
The various twine of light, by thee diſclos'd
From the white mingling maze.

And more copiouſly ſtill, in his poem to the memory of that divine philoſopher:

Light itſelf, which every thing diſplays,
Shone undiſcover'd, till his brighter mind
Untwiſted all the ſhining robe of day;
And, from the whitening undiſtinguiſhed blaze,
Collecting ev'ry ray into his kind,
To the charm'd eye educed the gorgeous train
Of parent colours. Firſt the flaming red
Sprung vivid forth; the tawny orange next;
And next delicious yellow; by whoſe ſide
Fell the kind beams of all refreſhing green.
Then the pure blue, that ſwells autumnal ſkies,
Ethereal play'd; and then, of ſadder hue,
Emerged the deepen'd indigo, as when
The heavy-ſkirted evening droops with froſt.
While the laſt gleamings of refracted light
Dy'd in the fainting violet away.
Theſe, when the clouds diſtil the roſy ſhower,
Shine out diſtinct adown the watery bow;
While o'er our heads the dewy viſion bends
Delightful, melting on the fields beneath.
Myriads of mingling dies from theſe reſult,
And myriads ſtill remain; infinite ſource
Of beauty, ever bluſhing, ever new!

But from poetical illuſtrations I ſhall proceed to a more minute diſcuſſion of this ſubject. A ray of light falling upon a glaſs priſm, breaks there, and is divided into ſeven principal rays, each of which bears its proper colour. The oblong image which this ſort of refraction produces, affords ſeven coloured ſtripes, diſtributed in a regular order. The firſt, reckoning from the upper part of the image, is red; the ſecond, orange; the third, yellow; the fourth, green; the fifth, blue; the ſixth, indigo; the ſe-

venth, violet. These stripes do not glare; but the eye passes from the one to the other by gradations or shades.

The rays which bear the highest colours, as the red, orange, and yellow, are those that break, refract, or curve the least in the prism. They are also such as reflect the first, on inclining the instrument. And hence it follows, that each ray has its essence or degree of refrangibility. If one of these rays is made to pass through several prisms at the same time, it will afford no new colours, but will constantly retain its primitive colour. This is an invincible proof of its immutability; for colours are not merely modifications arising from refraction or reflection, but immutable properties, and such as belong to the nature of the rays.

If a lens be presented to seven rays divided by the prism, they will be reunited into a single ray, which will exhibit a round image of a shining white. If only five or six of these rays be taken with the lens, it will produce but a dusky white. Two rays only reunited, will afford a colour that partakes of both. A stream of light, therefore, is a cluster of seven rays, whose reunion forms white, and the division of which produces seven principal and immutable colours.

What then is the source of that infinite diversity of colours, which causes such variety in bodies, and embellishes every part of our abode? From certain *lamellæ*, or thin particles, that compose the surface of bodies, and which are so many little prisms, variously inclined, that break the light, and reflect different colours. Gold divided into very thin plates, appears blue, when opposed to broad daylight. Those matters which corrode and split the mass of parts, change their complexions; and, consequently, the greater or less thickness of the lamellæ or thin plates, contributes likewise to the diversity of colours.

Whence proceeds that beautiful azure which tinges the canopy of heaven?—The ground of the heavens is black; and this ground viewed through the body of air that ſurrounds us, muſt appear blue to us by tranſmiſſion.

Whence proceeds the ſmiling verdure that adorns the fields, and delights the eye? The lamellæ of the ſurface of plants are made and diſpoſed in ſuch a manner, that they emit only green rays, while they afford a free paſſage to other rays. If green more particularly pleaſe the ſight, it is becauſe it holds an exact medium between the ſeven principal colours. But who can be inſenſible of the care that Nature has taken to depart from uniformity in this caſe, by multiplying the ſhades of green into ſuch an infinite variety. Some writers of great diſtinction have made it an argument for Providence, that the whole earth is covered with green rather than with any other colour, as being ſuch a right mixture of light and ſhade, that it comforts and ſtrengthens the eye, inſtead of weakening and grieving it. The poets, therefore, apply to this particular colour the epithet *cheerful*; and by Thomſon it is thus apoſtrophized:

Gay Green!
Thou ſmiling Nature's univerſal robe!
United light and ſhade! where the ſight dwells
With growing ſtrength, and ever new delight!

The rainbow, that beautiful phenomenon, diſplays at once all the colours of the priſm. How enchanting are the beauty and vivacity of its ſhades! One might imagine that Nature muſt have been at a vaſt expence to form ſuch a magnificent arch; but philoſophy teaches us, that ſome drops of water, on which the light breaks and reflects in different angles, are the ſole cauſe of the glorious ſpectacle.

What ſplendour in the gliding of ſome inſects! What richneſs in the ſcales of fiſhes! Nature, al-

ways magnificent in deſign, but frugal in execution, produces theſe briliant decorations with little coſt. She applies only a brown and pretty thin ſkin on a whitiſh ſubſtance: this ſkin performs the office of varniſh to our gilded ſkins: it modifies the rays which iſſue from the ſurface it covers. Theſe obſervations have been extended alſo to the leaves of plants, the enamelling of flowers, and to the colouring of fruits. In a word, the nature, origin, and properties of colours, in all their infinite varieties, would afford inexhauſtible ſubjects of contemplation; curious to the ſpeculative inquirer, and inſtructive to the virtuous philoſopher.

I ſhall conclude this philoſophical diſquiſition with ſome moral reflections from an elegant writer, who adduces the beauty ſo apparent in the whole creation, as an argument of the benignity of the Great Creator to mankind. "He has made every thing that is beautiful in all other objects pleaſant, or rather has made ſo many objects appear beautiful, that he might render the whole creation more gay and delightful. He has given almoſt every thing about us the power of raiſing an agreeable idea in the imagination: ſo that it is impoſſible for us to behold his works with coldneſs or indifference, and to ſurvey ſo many beauties without a ſecret ſatisfaction and complacency. Things would make but a poor appearance to the eye, if we ſaw them only in their proper figures and motions. And what reaſon can we aſſign for their exciting in us many of thoſe ideas which are different from any thing that exiſts in the objects themſelves (for ſuch are light and colours) were it not to add ſupernumerary ornaments to the univerſe, and make it more agreeable to the imagination? We are every where entertained with pleaſing ſhows and apparitions, we diſcover imaginary glories in the heavens and in the earth, and ſee ſome of this viſionary beauty poured out upon the whole creation;

but what a rough unſightly ſketch of nature ſhould we be entertained with, did all her colouring diſappear, and the ſeveral diſtinctions of light and ſhade vaniſh? In ſhort, our ſouls are at preſent delightfully loſt and bewildered in a pleaſing deluſion; and we walk about like the enchanted hero in a romance, who ſees beautiful caſtles, woods, and meadows; and, at the ſame time, hears the warbling of birds, and the purling of ſtreams; but, upon the finiſhing of ſome ſecret ſpell, the fantaſtic ſcene breaks up, and the diſconſolate knight finds himſelf on a barren heath, or in a ſolitary deſert. It is not improbable but ſomething like this may be the ſtate of the ſoul after its firſt ſeparation, in reſpect to the images it will receive from matter; although, indeed, the ideas of colours are ſo pleaſing and beautiful in the imagination, that it is poſſible the ſoul will not be deprived of them, but perhaps find them excited by ſome other occaſional cauſe, as they are, at preſent, by the different impreſſions of the ſubtle matter on the organs of ſight".

Theſe reflections, which diſcover ſuch a delicate ſenſibility to the beauty of nature, and which contain ſuch a happy illuſtration of the author's idea, are grounded upon the doctrine of Mr. Locke, that light and colours, as apprehended by the imagination, are only ideas in the mind, and not qualities that have any exiſtence in matter.

XLVI. ON VISION.

With thought from prepoſſeſſion free, reflect
On ſolar rays, as they the light reſpect.
The beams of light had been in vain diſplay'd,
Had not the eye been fit for viſion made:
In vain the Author had the eye prepar'd
With ſo much ſkill, had not the light appear'd.

BLACKMORE.

Oculi - - - - Interpretes ac Nuntii Rerum.

CICERO.

LUCRETIUS is the only bard I can recollect, who has ornamented the philoſophy of viſion with poetical illuſtration. But his theory, which was that of his maſter Epicurus, however beautiful in poetry, has long vaniſhed before the accurate reſearches and ſuperior attainments of the moderns.

If the conſtruction of the univerſe were not ſo evident a proof of the exiſtence of a ſupremely wiſe and benevolent Creator, as to render particular arguments unneceſſary, the ſtructure of the eye might be offered as one, by no means the leaſt. This inſtance, among numberleſs others, demonſtrating, that the moſt exquiſite performances of art are infinitely ſhort of thoſe which are continually produced by the Divine Mechanic.

Of all the ſenſes, the ſight is that which furniſhes the ſoul with the quickeſt, moſt extenſive, and moſt varied perceptions. It is the fertile ſource of the richeſt treaſures of imagination, and it is to that principally, that the ſoul owes the ideas of beauty, and of that *varied unity* which enchants it.

"Our ſight (as obſerved by an admirable writer) is the moſt perfect and delightful of all our ſenſes. It fills the mind with the largeſt variety of ideas,

converses with its objects at the greatest distance, and continues the longest in action, without being tired or satiated with its proper enjoyments. The sense of feeling can indeed give us a notion of extension, shape, and all other ideas that enter at the eye, except colours; but, at the same time, it is very much straitened and confined in its operations, to the number, bulk, and distance of its particular objects. Our sight seems designed to supply all these defects, and may be considered as a more delicate and diffusive kind of touch, that spreads itself over an infinite multitude of bodies, comprehends the largest figures, and brings into our reach some of the most remote parts of the universe".

Night has gradually withdrawn her sable curtain from the face of the earth. Aurora proclaims the approach of the glorious sun. He appears, and all nature seems to have received a new creation. What majesty! what splendour! what light! what colours!

But by what secret mechanism are my eyes made capable of communicating to me such lively, varied, and infinite perceptions? How do I discover with so much facility and quickness every object that surrounds me?

The eye is composed of several tunics, or coats, one within the other, and is filled within with transparent humours of different refractive densities. The external tunic, called the *sclerotica*, is white on the anterior part, except a circular portion immediately in front, which is transparent, and more convex than the rest of the eye: this transparent part is called the *cornea*. Immediately adherent to the *sclerotica* within, is the *choroides*, or *uvea*, which, at the circumference of the *cornea*, becomes the *iris*, being expanded over great part of its surface, though not contiguous to it. The *iris* is composed of two kinds of muscular fibres; the one sort tend, like the

radii of a circle, toward its centre, and the others form a number of concentric circles round the ſame centre. The central part of the *iris* is perforated, and the orifice, which is called the *pupil*, is of no conſtant magnitude; for, when a very luminous object is viewed, the circular fibres of the *iris* contract, and diminiſh its orifice; and, on the other hand, when objects are dark and obſcure, the radial fibres of the *iris* contract, and enlarge the *pupil*, ſo as to admit a greater quantity of light into the eye. The *iris* is variouſly coloured in different perſons, but according to no certain rule. In general, they whoſe hair and complexion are light-coloured, have the *iris* blue or gray; and, on the contrary, they whoſe hair and complexion are dark, have the *iris* of a deep brown. But what ſpecific difference this may occaſion in the ſenſe, or whether any at all, is not diſcoverable. Within the *uvea* is another membrane, which, at the circumference of the *cornea*, becomes fibrous, and is called the *ligumentum ciliare*. This ligature is attached to the circumference of a double convex lens, whoſe axis correſponds with the centre of the pupil, and which, by means of the fibres, can be altered, in a ſmall degree, in poſition, and perhaps in figure. This lens is termed the cryſtalline humour; and is included in a very ſtrong and tranſparent membrane called the *arachnoides*. Between the cryſtalline humour and the *cornea* is contained a clear tranſparent fluid, called the aqueous humour; and between the cryſtalline humour and the poſterior part or bottom of the eye, is included another clear tranſparent fluid, which is called the vitreous humour. The refractive denſity of the cryſtalline is greater than thoſe of the humours that ſurround it. On the ſide next to the noſe, a nerve is inſerted in the bottom of each eye, about twenty-five degrees from the axis of the cryſtalline, which, after entering the eye, is ſpread into an exceeding

fine coat of network, termed the *retina*. Laſtly, a very black mucus or ſlime, is ſpread over all the internal parts of the eye, that are not tranſparent, except the anterior part of the *iris*, which, as before obſerved, is coloured.

From this account of the ſtructure of the eye, I ſhall proceed to that of viſion, or the act of perceiving external objects by the organs of ſight. And this is well defined to be a ſenſation, by which, from a certain motion of the optic nerve, máde in the bottom of the eye by the rays of light emitted or reflected from objects, and hence conveyed to the common ſenſory in the brain, the mind perceives the luminous object, its quantity, quality, figure, &c. And thus, all the modern philoſophers, whether Carteſians or Newtonians, agree, that viſion is performed by rays of light, reflected from the ſeveral points of objects received in at the pupil, refracted and collected in their paſſage, through the coats and humours before-mentioned, to the retina; and thus ſtriking, or making an impreſſion, on ſo many points of it; which impreſſion is conveyed to the brain, &c. by the correſpondent capillaments, or fibres, of the optic nerve.

The cornea, or ſecond coat of the eye, being of a convex figure, performs the office of a glaſs lens. To illuſtrate this by a familiar example, put a glaſs lens into a hole made in the window ſhutter of a dark room; preſent a paſteboard to this lens; and you will immediately have a picture, in which all the objects without will be painted to the greateſt preciſion, and according to all the rules of the moſt exact perſpective. It will be like a moving picture whenever theſe objects move. You will then ſee rivers ruſhing down from the tops of mountains, and meandering in the plains; birds hovering in the air; fiſhes ſporting on the ſurface of the water;

flocks friſking in the meadows; and, in fine, all the poſſible varieties of proſpect.

Subſtitute inſtead of the lens the real eye of an ox, newly ſtript of its teguments, and you will ſee the ſame picture on the membrane which covers the bottom of it; but all the figures will be painted in a much ſmaller ſize. You can never be tired of admiring the extreme delicacy of this piece of miniature, and you will be aſtoniſhed to behold a field, fifteen or twenty miles ſquare, exactly delineated on a piece of vellum of a few lines in length.

The ſtructure of the eye of an ox is the ſame, with reſpect to the eſſential parts of it, as that of ours; and thus the mechaniſm of viſion is explained. The humours of the eye are the lens of the camera obſcura; the retina is the paſteboard. The black ſkin, which hangs within the pupil, performs the office of a ſhutter that excludes the light—it extinguiſhes the rays whoſe reflection would render the image leſs diſtinct. The pupil, by contracting or dilating itſelf in proportion to the ſtrength of the light, moderates the action of the rays on the retina; and the nerve, placed behind this, communicates to the brain, as before obſerved, the various concuſſions it receives, and to which various perceptions correſpond.

In the theory of viſion there are many curious phenomenons, which have exerciſed the ingenuity of the moſt learned men. Whence comes it, for inſtance, that all external objects are painted inverted on the retina, and that we ſee them, nevertheleſs, in their real ſituation? Whence is it, that objects of the greateſt magnitude are delineated on the eye with extreme minuteneſs, and yet we perceive every thing in its proper ſize? Whence is it, that if we look down from the top of St. Paul's cathedral in London, we ſee beneath us many thouſand houſes of that great metropolis, each painted ſo exactly in our

eye in a ſpace hardly three times larger than the head of a pin? So many millions of rays enter by a very ſmall aperture; they are united on the retina at the bottom of the eye, without confuſion, and conſtantly preſerving the ſame order which the points of the objects had that emitted them. Let us aſcend a high rock, and obſerve a fleet in full ſail at ſea; let us contemplate the ſea itſelf, and what millions of waves may be diſcovered! Each of theſe, nevertheleſs, reflects maſſes of rays upon our eye, the ſize of which is ſo minute. In an extenſive country proſpect, every tree, and even every blade of graſs, emits its rays; without which it would be impoſſible for us to perceive the uninterrupted verdure of all the fields beneath us. Is it not wonderful too, that we do not ſee objects double; and that although we have two eyes, each object ſtill appears but one?

But there is another circumſtance to excite our admiration. The objects we behold are not viſible to us alone: we have juſt obſerved, with aſtoniſhment, the number of rays they ſend on a ſpace ſo ſmall as that occupied by the pupil of the eye. They all ſend as many more to every part of the maſs of air that ſurrounds them. Wherever, therefore, we may remove, new rays replace the firſt, and render the ſame objects viſible to us, that we had ſeen in our former ſituation. All the rays neceſſary to effect this had exiſted before, and waited only for eyes. But the rays admitted into the eye are not all equally efficacious. Beſide theſe, there are innumerable others, which, being much weaker, are effaced by the ſplendour of the firſt, but which are conſtantly ready to perform the ſame functions, if neceſſary.

But how few are there who reflect on the wonderful phenomenons of viſion? From the habit of ſeeing, the inſtant we open our eyes, we are apt to regard this operation as a thing extremely ſimple, and eaſy to be underſtood. Nevertheleſs we are ſtill

far remote from an ability to explain all the phenomenons of viſion. We know, indeed, how the image is formed at the bottom of the eye; we know alſo, what all the parts of the eye contribute to this. But this is not ſufficient; for the eye itſelf can have no idea of what paſſes within it. It is neceſſary, therefore, that the impreſſion which the rays make upon it ſhould be propagated to the brain, and that, to accompliſh this, the rays paint the image on a network of nerves which correſpond to thoſe of the brain. In this manner, the motion impreſſed by the rays on the nerves of the retina, is tranſmitted to the brain by the optic nerve; but beyond this we can deſcribe no more; for we do not perfectly know the nature of the brain, nor the uſe of its various parts.

We know enough, however, to induce us to admire and to adore the unſpeakable power, and wiſdom, and goodneſs of God. Whatever remains inacceſſible to our comprehenſion, is the work of a Supreme Intelligence, conſpicuous in every object, whether in ourſelves, or in every thing that ſurrounds us; an Intelligence, which never ceaſes to employ the wiſeſt means to accompliſh the moſt benevolent ends.—The great philoſopher of antiquity, in his treatiſe *De Naturâ Deorum*, was ſenſible of the wiſdom and contrivance diſplayed in the conſtruction of the eye: "What artificer but Nature, whoſe direction is incomparable, could ſo artfully have formed the ſenſes? She has covered and inveſted the eyes with the fineſt membranes, which ſhe has made tranſparent, that we may ſee through them, and firm in their texture, to preſerve the eyes. She has made them ſlippery and moveable, that they might avoid what would offend them, and eaſily direct the ſight wherever they will. The point of ſight, which is called the pupil, is ſo ſmall, that it can eaſily ſhun whatever may be hurtful to it. The eyelids, which

are their coverings, are soft and smooth, that they may not injure the eyes, and are made to shut at the apprehension of any accident, or to open at pleasure; and these movements Nature has ordained to be made in an instant. They are fortified with a sort of palisade of hairs, to keep off what may be noxious to them when open, and, when sleep closes them, to be a fence to their repose. Besides, they are commodiously defended by eminences on every side; for, on the upper part, the eyebrows turn aside the sweat that falls from the forehead; the cheeks beneath, having a little rising, protect the lower; and the nose is placed between as a wall of separation".

XLVII. ON SOUND AND THE SENSE OF HEARING.

> Auditur sonus, et vox omnis, in aures
> Insinuata suo pepulere ubi corpore sensum.
>
> LUCRETIUS.

> Mark how the spirits, watchful in the ear,
> Seize undulating sounds, and catch the vocal air.
>
> BLACKMORE.

SOUND may be defined to be a perception of the soul, communicated by means of the ear; or the effect of a collision of bodies, and a tremulous motion in consequence of that collision, communicated thence to the circumambient fluid, and propagated through it to the organs of hearing.

To explain this definition I must observe, that when obtuse bodies move in elastic fluids, they condense that part toward which they move, at the same time that the part from which they recede is rarefied.

This condenſation, or rarefaction, muſt produce an undulatory or vibrating motion in the fluid. Thus, if a body, by percuſſion or otherwiſe, be put into a tremulous motion, every vibration of the body will excite a wave in the air, which will proceed in all directions ſo as to form a hollow ſphere[a]; and the quicker the vibrations of the body ſucceed each other, the leſs will be the diſtance between each ſucceſſive wave. The ſenſation excited in the mind by means of theſe waves, which enter the ear, and produce a like motion in a thin membrane, ſtretched obliquely acroſs the auditory paſſage, is called ſound. But the term is frequently uſed to imply, not only the ſenſation excited in the mind, but likewiſe the affection of the air, or of the ſonorous body by which that ſenſation is produced. Thus, we ſay, that a ſound is in the air, or that a body ſounds when ſtruck, although the affection of the air or body is very different from the ſenſation.

That bodies move or tremble when they produce ſound, requires no particular proof: it is evident in drums, bells, and other inſtruments, whoſe vibrations being large and ſtrong are, therefore, more perceptible: and it is equally clear, that a ſimilar vibration is excited in the air, becauſe this vibration is communicated through the air to other bodies, that are adapted to vibrate in the ſame manner: thus bells, glaſſes, baſins, and muſical ſtrings, will ſound merely by the action propagated from other ſounding bodies.

It is eſtabliſhed, as well by mathematical reaſoning from the nature of an elaſtic fluid, as from experiment, that all ſounds whatever arrive at the ear in equal times from ſounding bodies equally diſtant.

[a] The ſame is viſible when a ſtone is thrown into ſtagnating water: the waves excited thereby continue ſome time to riſe in the place where the ſtone fell into the water, and are propagated thence in concentric circles, upon the ſurface of the water, to great diſtances.

This common velocity is 1142 English feet in a second of time. The knowledge of the velocity of sound is of use, for determining the distances of ships, or other objects: for instance, suppose a ship fires a gun, the sound of which is heard five seconds after the flash is seen; then, 1142 multiplied by 5, gives the distance 5710 feet, or one mile and 430 feet.

When the aërial waves meet with an obstacle which is hard, and of a regular surface, they are reflected, and consequently, an ear placed in the course of these reflected waves will perceive a sound similar to the original sound, but which will seem to proceed from a body situate in like position and distance behind the plane of reflection, as the real sounding body is before it. This reflected sound is called an echo.

This echo, or repercussion of sounds, is chiefly observable in smooth, tortuous, and hollow places, as in vallies, caves, and walls, especially in old vaulted buildings. An echo, therefore, as a pleasing, and very often wonderful circumstance, could not fail to enter into poetical descriptions, and to be the subject of fiction and personification. The Hebrews styled Echo *the daughter*, and the Greeks and Latins, *the image of the voice*. Thus Virgil:

Aut ubi concava pulsu
Saxa sonant, vocisque offensa resultat imago.

Nor hollow rocks that render back the sound,
And doubled images of voice rebound. DRYDEN.

And Horace:

- - - - - cujus recinet jocosa
Nomen imago.
Aut in umbrosis Heliconis oris,
Aut super Pindo, gelidove in Hæmo.

- - - - - whoſe hallow'd name
The ſportive image of the voice
Shall in the ſhades of Helicon repeat,
On Pindus, or on Hæmus ever cool. FRANCIS.

In the third book of Ovid's Metamorphoſes is the beautiful fiction of the Transformation of Echo, to which I muſt refer the reader; but the following extract from Addiſon's tranſlation of it affords an admirable deſcription of an echo:

Echo in others words her ſilence breaks,
Nor ſpeaks herſelf but when another ſpeaks.
She can't begin, but waits for the rebound,
To catch his voice, and to return the ſound.
Hence 'tis ſhe prattles in a fainter tone,
With mimic ſounds, and accents not her own;
Lives in the ſhady coverts of the woods,
In ſolitary caves, and dark abodes.

But nothing can exceed the exquiſite ſong in Milton's Comus:

Sweet Echo, ſweeteſt nymph, that liv'ſt unſeen
Within thy aëry ſhell,
By ſlow Meander's margent green,
And in the viölet-embroider'd vale,
Where the love-lorn nightingale
Nightly to thee her ſad ſong mourneth well;

Canſt thou not tell me of a gentle pair
That likeſt thy Narciſſus are?
O if thou have
Hid them in ſome flow'ry cave,
Tell me but where,
Sweet queen of parly, daughter of the ſphere,
So may'ſt thou be tranſlated to the ſkies,
And give reſounding grace to all Heav'n's harmonies.

Milton, moreover, makes a noble poetical uſe of the philoſophy of echos in Adam's morning hymn:

Witneſs if I be ſilent, morn or even,
To hill or valley, fountain, or freſh ſhade,
Made vocal by my ſong, and *taught his praiſe*.

And to this he makes Adam pathetically allude, in his lamentation after the fall:

O woods, O fountains, hillocks, dales and bowers,
With other echo late I taught your ſhades
To anſwer, and reſound far other ſong!

But I muſt return to a philoſophical diſcuſſion of the ſubject. The waves of ſound being thus reflexible, nearly the ſame, in effect, as the rays of light, may be deflected, or magnified, by much the ſame contrivances as are uſed in optics. From this principle of reflection it happens, that ſounds uttered in one focus of an elliptical cavity are heard much magnified in the other focus; inſtances of which are found in ſeveral domes and vaults, particularly in the whiſpering gallery at St. Paul's cathedral in London, where a whiſper uttered at one ſide of the dome is reflected to the other, and may be very diſtinctly heard. On this principle alſo is conſtructed the ſpeaking trumpet, which either is, or ought to be, a hollow parabolic conoid, having a perforation at the vertex, to which the mouth is to be applied in ſpeaking, or the ear in hearing.

But to what purpoſe would be all theſe obſervations on the nature and properties of ſound, if the human frame were not made capable of receiving it? How adorable then is the goodneſs of the great Creator, in having not only diſpoſed the air in ſuch a manner, that ſound may be produced by its vibrations, but in having given us an organ capable of receiving theſe ſonorous vibrations.

The poſition of the ear is admirable; for it is placed in the moſt convenient part of the body, near the brain, the common ſeat of all the ſenſes, to give

the more ſpeedy information; in a part, where it can be beſt guarded; and in the neighbourhood of its ſiſter ſenſe, the eye, with which it has a peculiar and admirable communication by its nerves.

The ſtructure alſo of the ear, no leſs than its poſition, may evince wiſdom, intelligence, and deſign. The ear may be conſidered as exterior and interior. And if we obſerve the ſtructure of the exterior ear in all kinds of animals, we cannot but perceive how wonderfully it is adapted to the reſpective exigencies of each. In man it is of a form proper for the erect poſture of his body: in birds, of a form proper for flight, not protuberant, which would obſtruct their progreſs, but cloſe and covered, to afford the eaſier paſſage through the air. In quadrupeds, its form is agreeable to the poſture, and ſlower motion, of their bodies; and in theſe too, various, according to their various occaſions: in ſome, large, erect, and open, to hear the leaſt approach of danger: in others, covered, to keep out noxious bodies. In ſubterraneous quadrupeds, which are forced to mine and dig for their food and habitation, as a protuberant ear, like that of other quadrupeds, would obſtruct their labours, and be liable to be torn and injured, their ears, on the contrary, are ſhort, lodged deep, and backward in the head, paſſing to the under part of it, and all ſufficiently fenced and guarded. To mention one inſtance only; the mole is, in this reſpect, a ſubject of curious diſcuſſion: it has no protuberant ear, but only a round hole between the neck and ſhoulder, and this ſituation, with the thick ſhort fur that covers it, is a ſufficient defence againſt all external annoyance.

And, as the form is various in various animals, ſo, in each of them, its ſtructure is very curious and obſervable; being admirably contrived to collect the wandering circumambient impreſſions, and undulations of ſound, and to convey them to the ſenſory

within.—But I ſhall now confine my ſurvey to the human ear.

The firſt thing we obſerve is the auricle, or external ear, with its tortuous cavities, formed to ſtop and collect the ſonorous undulations, to give them a gentle circulation and refraction, and ſo convey them to the concha, or large capacious round cell, at the entrance of the ear. And the great contrivance viſible in the outward ear, is in nothing more apparent than in this circumſtance, that they whoſe ears are cut off, have but a confuſed way of hearing, and are obliged either to form a cavity round the ear with their hand, or elſe to make uſe of a hearing trumpet to ſupply the defect. The cartaliginous ſubſtance of the outward ear, is likewiſe, very obviouſly, another wiſe proviſion of the great Creator.

In the interior part of this admirable organ we may obſerve, in the firſt place, the auditory paſſage, curiouſly tunnelled and turned, to give ſounds an eaſy paſſage, as well as a gentle circulation and refraction, and likewiſe to prevent their too furiouſly ruſhing in, and aſſaulting the more tender internal parts.

To prevent, moreover, the entrance of noxious inſects, which are apt to make their retreat in every little hole, Nature has ſecured this paſſage with a bitter nauſeous ſubſtance, called earwax, which is ſupplied by the glands appointed for that purpoſe.

The next principal thing to be obſerved, is the membrana tympani, or drum of the ear, with its inner membrane, the four little appendant bones, and the three inner muſcles to move them, and to adjuſt the whole ſyſtem to the ſeveral purpoſes of hearing, to hear loud or ſoft, diſcordant or agreeable ſounds.

The paſſage juſt behind the drum of the ear is called the veſtibulum, being, as it were, the antichamber or entrance to two other cavities. The firſt of theſe is called the labyrinth, and conſiſts of certain ſemicircular canals; and the ſecond is called

cochlea, from its reſemblance to a ſnail ſhell. The labyrinth appears to have ſomething of the mechaniſm and uſes of a hearing trumpet; while the cochlea appears to be deſtined for the more delicate and refined uſes of hearing, ſuch as the forming and modulating of muſical and harmonious ſounds.

There is one particular contrivance of the nerves miniſtring to this ſenſe of hearing, that muſt not be paſſed over; which is, that the branches of one of the auditory nerves ſpread partly to the muſcles of the ear, partly to the eye, partly to the tongue and inſtruments of ſpeech, and inoſculated with the nerves to go to the head and breaſt. By theſe means, there is an admirable and uſeful conſent between the parts of the body; it being natural for moſt animals, upon the hearing of any uncouth noiſe, to erect their ears, and prepare them to catch every ſound; to open their eyes, thoſe conſtant faithful centinels, to ſtand upon the watch; and to be ready with the mouth to cry out, and utter what the preſent exigency may ſuggeſt. And this is, accordingly, uſual for moſt animals, when ſurpriſed or terrified by any frightful noiſe.

Such is the nature and properties of ſound, and ſuch the admirable ſtructure and uſes of the ear. If it be aſked why, when a word is pronounced, it excites a certain idea, and not a ſimple tone; or how a ſound can act upon the ſoul, and produce ſo many different notions; we are obliged, in this reſpect, to confeſs our abſolute ignorance.

We know enough, however, to be aſſured, that the ear is one of the moſt convincing proofs in nature of the divine wiſdom and goodneſs; and well may we exclaim with the royal Pſalmiſt, "Such knowledge is too wonderful for me: it is high, and I cannot attain unto it. But I will praiſe thee, O Lord; for I am fearfully and wonderfully made".

XLVIII. ON THE SMELL, TASTE, AND TOUCH.

Next in the noſtrils ſhe doth uſe the Smell,
As God the breath of life in them did give:
So makes He now this power in them to dwell,
To judge all airs whereby we breathe and live.

DAVIES.

Taſte after Taſte upheld with kindlieſt change.

MILTON.

By Touch the firſt pure qualities we learn,
Which quicken all things, hot, cold, moiſt, and dry;
By Touch, hard, ſoft, rough, ſmooth, we do diſcern;
By touch, ſweet pleaſure and ſharp pain we try.

DAVIES.

BEFORE I enter into a conſideration of the remaining ſenſes, the Smell, Taſte, and Touch, I ſhall make ſome obſervations upon the Senſes in general. By certain wonderful organs of the body, man is ſuſceptible of a variety of ſenſations. We have ſeen, that by the eyes, he can acquire the perception of light and colours; and, by the ears, the perception of different tones. By the ſmell and taſte, moreover, he perceives certain agreeable or diſagreeable emanations, ſavours and odours, ſweet and bitter, and other ſimilar properties in the bodies or ſubſtances which approach the noſe, or are admitted into the mouth. And, finally, by the touch, which is diffuſed over the whole body, he has the ſenſations of heat and cold, of moiſt and dry, of ſoft and hard, &c.

Theſe five ſenſes, thus uſeful to man, and indeed eſſential to his happineſs, have been the ſubject of poetical illuſtration, in one of the earlieſt periods of Engliſh verſification. Sir John Davies, who flou-

riſhed in the reign of queen Eliſabeth, thus expreſſes himſelf, in his excellent poem on the Immortality of the Soul.

This pow'r is ſenſe, which from abroad doth bring
The colour, taſte, and touch, and ſcent, and ſound,
The quantity and ſhape of every thing
Within earth's centre or heaven's circle found:

And though things ſenſible be numberleſs,
But only five the ſenſe's organs be;
And in thoſe five all things their forms expreſs,
Which we can touch, taſte, ſmell, or hear, or ſee.

* * * * *

Then is the ſoul a nature, which contains
The pow'r of ſenſe within a greater pow'r,
Which doth employ and uſe the ſenſe's pains;
But ſits and rules within her private bow'r.

* * * * *

If we had nought but ſenſe, then only they
Should have ſound minds which have their ſenſes ſound;
But wiſdom grows when ſenſes do decay,
And folly moſt in quickeſt ſenſe is found.

The ſenſe next in order, after thoſe of ſight and hearing, which we have been already diſcuſſing, is Smell, which is that act whereby we become ſenſible of odorous bodies. The principal organs of this ſenſe are the noſtrils and olfactory nerves; the minute ramifications of which latter are diſtributed throughout the whole concave of the former.

Smelling is performed by the odorous effluvia, flowing in the air, being drawn into the noſtrils, by inſpiration, and ſtruck with ſuch force againſt the fibrillæ of the olfactory nerves, as to ſhake them, and give them a vibratory motion; which action being communicated thence to the common ſenſory, occaſions an idea of a ſweet, or fetid, or ſour, or aromatic, or putrefied object, &c. And it is obſerved by the great Boerhaave, that the matter ot

animals, vegetables, foſſils, &c. which chiefly affects the ſenſe of ſmelling, is that ſubtile ſubſtance, inherent in the oily parts thereof, called *ſpirits*; becauſe, when this is taken away from the moiſt fragrant bodies, what remains has ſcarce any ſmell at all; but this, poured on the moſt inodorous bodies, will give them fragrancy.

Brutes have generally the ſenſe of ſmelling in much greater perfection than man; as by this alone they diſtinguiſh the virtues and qualities of bodies unknown before; hunt out their food at a great diſtance, as hounds and birds of prey; or find it hid among other ſubſtances, as hogs and ducks. But man, having other means of judging of his food, does not need ſo much ſagacity in his noſe.

Dr. Derham obſerves, that although the apparatus for ſmelling be ſufficiently grand and admirable, it is not ſo complicated as that of the eye and ear; it being ſufficient in this ſenſe, that the odoriferous effluvia of bodies have a free and eaſy paſſage to the olfactory nerves, without the formalities of refractions, and other preparations neceſſary to the perfection of the two former ſenſes. And, accordingly, the All-wiſe Creator has made ſufficient proviſion for the reception of ſmells, by the apertures of the noſtrils, which are not made of fleſh and bone, but are cartilaginous, the better to be kept open, as well as to be dilated or contracted, as occaſion may require; for which ſervice it has ſeveral curious and proper muſcles.

As it is by inſpiration, moreover, that the odorous particles are inhaled, and conveyed to the ſenſory, there is another very wiſe proviſion in the laminæ with which the upper part of the noſe is barricaded, and which ſerve two excellent purpoſes; partly to fence out any noxious ſubſtances from entering the breathing paſſages in our ſleep, or when not aware of them; and, partly, to receive

the divarications of the olfactory nerves. And it is found, that these laminæ are always larger, and folded up together in greater numbers, in proportion as the animal has this sense more accurate; their various windings and turnings detaining and fettering a great quantity of the odoriferous particles.

The Taste may be defined to be that sensation which all things, taken into the mouth, give particularly to the tongue, the papillæ of which are the principal instruments thereof. These papillæ are so called from their resemblance to little paps, and, when viewed in the microscope, appear like the pile of velvet. But the greatest writers have differed on this subject. Some consider the palate, the upper part or roof of the mouth, to be the instrument of taste. Of this last opinion is Mr. Locke, who observes, that " light and colours come in only by the eyes, all kinds of sounds only by the ears, the several tastes and smells by the nose and palate". This opinion is ludicrously alluded to by Prior, in his poem of Alma:

By nerves about our palate placed,
She [a] likewise judges of the taste:
Else, dismal thought! our warlike men
Might drink thick port for fine Champagne.

But whether the organ of taste be seated in the tongue or in the palate, the Divine Wisdom is not less apparent in this sense than in all the others. The judicious Derham observes, that our Creator seems to have established a great consent between the eye, the nose, and tongue, by ordering the branches of the same nerves to each of these three parts, as also, indeed, to various other parts of the body: by which means there is all the guard that can be against pernicious food; since, before it be

[a] Alma, the Mind.

admitted into the ſtomach, it is to undergo the trial of three of the ſenſes; the ſcrutiny of the eye, that ſtrict ſurveyor of its outward appearance, and the probation of the ſmell and taſte, the two ſevereſt judges of its natural conſtitution and compoſition.

The Touch, or Feeling, is the fifth ſenſe; by which we acquire the ideas of ſolid, hard, ſoft, rough, hot, cold, whet, dry, or other tangible qualities; as alſo of diſtance, itching, pain, &c. It is the groſſeſt, but, at the ſame time, the moſt exquiſite of our ſenſes, having more objects than all the reſt taken together; and ſome even reduce all the other ſenſes to this one of feeling.

The lateſt and beſt authors hold the immediate organ of the ſenſe of feeling to be the pyramidal papillæ under the ſkin. Theſe papillæ are little, ſoft, medullary, nervous prominences, lodged every where immediately under the cûticle or outermoſt ſkin. They are formed of the ſubcutaneous nerves, which are largeſt and moſt conſpicuous in thoſe parts chiefly deſigned for the office of feeling; namely, the tongue, and the tips of the fingers and toes; and they are both contractible and expanſive at pleaſure. And, therefore, feeling is thus affected: the tip of the fingure, for inſtance, being applied to the object to be examined, by the intention of the mind the papillæ are emitted or elevated, and being ſlightly rubbed over the ſurface of the object, a motion is impreſſed on them, which being propagated thence by the nerves communicating with them to the common ſenſory, excites the perception of heat, cold, harſhneſs, or the like.—The nerves are ſpread in a manner incomparably curious throughout the whole body. But to deſcribe their origin in the brain and ſpinal marrow, their ramifications to all the parts, their inoſculations with one another, &c. by which not only the ſenſe of feeling is performed, but alſo animal motion, and an admirable conſent and harmony

between all the parts of the body is effected, more properly belongs to an anatomical account of the nervous ſyſtem.

Feeling is, on many accounts, the moſt univerſal of our ſenſes, no animal being without it; not even thoſe that are generally thought to have no other ſenſe, as oyſters and earthworms. Naturaliſts obſerve that ſpiders, flies, and ants have this ſenſe in much greater perfection than man; although we have inſtances of perſons who could diſtinguiſh colours by their feeling, and others who could perceive what people ſaid by the ſame ſenſe. In blind perſons the defect of ſight has been ſupplied by an exquiſite touch, or ſenſe of feeling, which they have had in ſuch perfection, that, as it has been ſaid of ſome, they learned to hear with their eyes, it may be ſaid of theſe, that they taught themſelves to ſee with their hands. A paſſage, therefore, in Shakſpeare's King Lear, which has been thought a fine boldneſs of expreſſion, is extremely natural and pathetic:

O dear ſon Edgar,
Might I but live *to ſee thee in my touch*,
I'd ſay, *I had eyes again*.

The diſperſion of the ſenſe of feeling throughout the body muſt not be unnoticed. The other ſenſes, it has been obſerved, are ſeated in the very beſt place for the relief and comfort, the guard and benefit of the animal: and as it was neceſſary both to the exiſtence and wellbeing of the body, that every part ſhould be ſenſible of things ſafe, or things prejudicial to itſelf, it is, therefore, an admirable contrivance of the great Creator, to diſperſe this ſenſe of feeling through every part, in order to diſtinguiſh between pleaſure and pain, and between what is ſalutary and what is hurtful.

In the account which I have thus given of the five ſenſes, in the preſent and two preceding papers,

it is evident that there is an economy in them worthy of the Creator, and manifeſtly demonſtrative of infinite power, wiſdom, and goodneſs. For, whether we conſider the mechaniſm of the organs, or the great uſe and convenience of each ſenſe, we find them noble and grand, curious and artificial, every way worthy of an omnipotent hand, and beyond the ſkill and contrivance of aught but Deity.

The Contemplative Philoſopher, then, will never fail to recollect, that what the Deity has thus provided for our uſe, was provided for the nobleſt ends. Tully, after expatiating, in his treatiſe *De Naturâ Deorum*, on the accurate diſcernment, and admirable uſes of the eye and ear, thus complains: "Our other ſenſes of ſmelling, taſting, and feeling, are likewiſe poſſeſſed of very acute diſcernments; for the gratification and indulgence of which, more arts have been invented than I could wiſh; for it is evident to what an extravagant degree the compoſition of perfumes, the ſeaſoning of meats, and other refinements of ſenſuality, have been carried".—Happy the philoſopher, happy the man, who diſdains the employment of ſuch faculties to the purpoſes of mere ſenſual enjoyment. How grateful ſhould he be, whoſe *ſight* enables him to avoid the various perils by which he is ſurrounded; to behold the magnificence of the heavens; the beauties of landſcape, and numberleſs diverſities of Creative Power: whoſe *hearing* renders him capable of guarding againſt every danger that may menace him at a diſtance; to engage in the ſweet intercourſes of rational converſation and endearing ſentiment; to receive from others the nobleſt leſſons of inſtruction; and to liſten with rapture, to the ſoothing charms of melody, or to the grander combinations of harmony: who, by his *ſmell* and *taſte*, can diſtinguiſh with accuracy, what is ſalutary from what is unwholeſome in his food, and can be ſuſceptible of the pleaſing ſenſations which reſult

from the fragrant beauties of ſpring, or the laviſh bounties of autumn: and, finally, whoſe *feeling* is ſo conducive to ſelf-preſervation, and productive, in ſuch a variety of reſpects, of exquiſite delight. He will recollect, that our ſenſes, by the ideas which they admit, are the ſources of ſtill nobler pleaſures— the pleaſures of the heart and underſtanding; which, cultivated with conſtant aſſiduity, are ſo many flowers ſtrowed along the paths that lead to heaven and immortality. For yet a little while, and the *eye* will be no longer charmed with the beauty of terreſtrial objects; the *ear* no longer captivated by the enchanting tones of muſic; the *ſmell* and *taſte* will be inſenſible to the moſt fragrant ſweets and the moſt delicious viands; and the *touch*, now ſuſceptible of ſuch exquiſite ſenſations, will ceaſe alike to affect with pleaſure or with pain: in a word, when nothing will remain but the memorial of virtuous fame, and (if worthy of ſuch felicity) a reſurrection to the bleſſedneſs of the juſt.

XLIX. ON LIGHTNING AND THUNDER.

Multa tamen reſtant, et ſunt ornanda politis
Verſibus, et ratio cœli, ſpecieſque tenenda:
Sunt tempeſtates, et fulmina clara canenda,
Quid faciant, et quâ de cauſâ cumque ferantur.

LUCRETIUS.

Lo, theſe are parts of his ways! But how little a portion is heard of him! But the thunder of his power who can underſtand? JOB.

Loud thunder, livid flames, and Stygian night,
Compounded horrors, all the deep affright.

BLACKMORE.

THE wonders of the Divine Wiſdom in our atmoſphere are inexhauſtible. Of that element itſelf, with various properties and beneficial uſes of it, and ſome of the moſt common meteors obſervable in it, I have already treated. But, as the philoſophical poet obſerves, in my firſt motto, "much ſtill remains to be diſcuſſed"; and, the more we extend our reſearches, the more ſhall we be convinced, with the venerable patriarch above, that we know but little in compariſon with the ſecrets of Nature that are yet unknown, and which, by mortals at leaſt, may continue for ever unexplored.

In our atmoſphere is obſervable a variety of meteors; that is, certain changeable, moveable, imperfect mixt bodies, or reſemblance of a body, formed of the matter that floats in the atmoſphere, and exhibiting various appearances. Theſe meteors [a] are

[a] The Greeks call them μετεωρα, that is, *ſublimia*, *high-raiſed*; the Latins *impreſſiones*, as making ſigns or impreſſions in the air.

either aërial, aqueous, or fiery. The aërial meteors consist of flatulent and spirituous exhalations; such as winds, whirlwinds, and hurricanes[a]: the aqueous kind are composed of vapours, or watery particles, variously separated, and condensed by heat and cold; such are clouds, rainbows, hail, snow, rain, dew, and the like[b]: and the fiery sort are lightning, aurora borealis, ignis fatuus, draco volans, falling stars, and other fiery phenomenons, appearing in the air. —Of these fiery meteors, the lightning, which is among the most formidable phenomenons of Nature, shall be the subject of this paper, and the others shall be treated of in a future one[c].

Agreeably to the method I have adopted, of enlivening my subject with poetical illustrations, whenever it would admit of it, I shall preface the philosophical theory with Thomson's celebrated description of a storm of thunder and lightning:

Behold, slow-settling o'er the lurid grove
Unusual darkness broods; and growing gains
The full possession of the sky, surcharg'd
With wrathful vapour, from the secret beds,
Where sleep the mineral generations, drawn.
Thence nitre, sulphur, and the fiery spume
Of fat bitumen, steaming on the day,
With various-tinctur'd trains of latent flame,
Pollute the sky, and in yon baleful cloud,
A reddening gloom, a magazine of fate,
Ferment; till, by the touch ethereal rous'd,
The dash of clouds, or irritating war
Of fighting winds, while all is calm below,
They furious spring. A boding silence reigns,
Dread through the dun expanse; save the dull sound
That from the mountain, previous to the storm,
Rolls o'er the muttering earth, disturbs the flood,

[a] See No. II, On Winds and Storms.
[b] See No. XLV, On Colours, for the phenomenon of the rainbow; and No. XII for an account of the other aqueous meteors.
[c] See No. LI.

And ſhakes the foreſt-leaf without a breath.
Prone, to the loweſt vale, th' aërial tribes
Deſcend: the tempeſt-loving raven ſcarce
Dares wing the dubious duſk. In rueful gaze
The cattle ſtand, and on the ſcowling heavens
Caſt a deploring eye; by man forſook,
Who to the crowded cottage hies him faſt,
Or ſeeks the ſhelter of the downward cave.
'Tis liſtening fear and dumb amazement all:
When to the ſtartled eye the ſudden glance
Appears far ſouth, eruptive through the cloud;
And following ſlower, in exploſion vaſt,
The thunder raiſes his tremendous voice.
At firſt, heard ſolemn o'er the verge of heaven,
The tempeſt growls; but as it nearer comes,
And rolls its awful burden on the wind,
The lightnings flaſh a larger curve, and more
The noiſe aſtounds: till over head a ſheet
Of livid flame diſcloſes wide; then ſhuts,
And opens wider; ſhuts and opens ſtill
Expanſive, wrapping ether in a blaze.
Follows the looſen'd aggravated roar,
Enlarging, deepening, mingling; peal on peal
Cruſh'd horrible, convulſing heaven and earth.
Down comes a deluge of ſonorous hail,
Or prone-deſcending rain. Wide-rent, the clouds
Pour a whole flood; and yet, its flame unquench'd,
Th' unconquerable lightning ſtruggles through,
Ragged and fierce, or in red whirling balls,
And fires the mountains with redoubled rage.
Black from the ſtroke, above, the ſmouldering pine
Stands a ſad ſhatter'd trunk; and, ſtretch'd below,
A lifeleſs group the blaſted cattle lie:
Here the ſoft flocks, with that ſame harmleſs look
They wore alive, and ruminating ſtill
In fancy's eye; and there the frowning bull,
And ox half-rais'd. Struck on the caſtled cliff,
The venerable tower and ſpiry fane
Reſign their aged pride. The gloomy woods
Start at the flaſh, and from their deep receſs,
Wide flaming out, their trembling inmates ſhake.
Amid Carnarvon's mountains rages loud

The repercuſſive roar: with mighty cruſh,
Into the flaſhing deep, from the rude rocks
Of Penmanmaur heap'd hideous to the ſky,
Tumble the ſmitten cliffs; and Snowden's peak,
Diſſolving, inſtant yields his wintery load.
Far-ſeen, the heights of heathy Cheviot blaze,
And Thulè bellows through her utmoſt iſles.

And more formidable ſtill is his deſcription of a thunder-ſtorm in the torrid zone:

In blazing height of noon,
The ſun, oppreſs'd, is plung'd in thickeſt gloom.
Still horror reigns, a dreary twilight round,
Of ſtruggling night and day malignant mix'd.
For to the hot equator crowding faſt,
Where, highly rarefy'd, the yielding air
Admits their ſtream, inceſſant vapours roll,
Amazing clouds on clouds continual heap'd!
Or whirl'd tempeſtuous by the guſty wind,
Or ſilent born along, heavy, and ſlow,
With the big ſtores of ſteaming oceans charg'd.
Meantime, amid theſe upper ſeas, condens'd
Around the cold aërial mountain's brow,
And by conflicting winds together daſh'd,
The thunder holds his black tremendous throne:
From cloud to cloud the rending lightnings rage;
Till, in the furious elemental war
Diſſolv'd, the whole precipitated maſs
Unbroken floods and ſolid torrents pours.

Lightning is a large, bright flame, darting ſwiftly through the air, and extending every way to a conſiderable diſtance, of momentary duration, and commonly attended with thunder; that is, with a noiſe in the loweſt region of the air, excited by the ſudden exploſion of electrical clouds; which, on this account, are called thunder-clouds.

To account for the phenomenon of lightning, ſome philoſophers have ſuppoſed, that from the particles of ſulphur, nitre, and other combuſtible mat-

ters, which are exhaled from the earth, and carried into the higher regions of the atmoſphere, is formed an inflammable ſubſtance, which, when a ſufficient quantity of fiery particles is ſeparated from the vapour buoyed up into the air, with theſe particles adhering to them, by the colliſion of two clouds or otherwiſe, takes fire, and ſhoots into a train of light, larger or leſs, according to the ſtrength and quantity of the materials. Others have explained lightning by the fermentation of the ſulphureous ſubſtances with nitrous acids.

Had the poet of the Seaſons lived at this period, his philoſophical theory of lightning would, no doubt, have been different: for, in the preſent advanced ſtate of the ſcience of electricity, lightning is univerſally allowed to be an electrical phenomenon. Philoſophers had not proceeded far in their experiments and inquiries on this ſubject, before they were ſtruck with the obvious analogy between lightning and electricity; and they produced many arguments, *à priori*, to aſcertain their ſimilarity. But the method of verifying this hypotheſis was firſt propoſed by Dr. Franklin, who, in the year 1749, conceived the practicability of drawing lightning from the clouds. Having found, by previous experiments, that the electric fluid is attracted by points, he apprehended that lightning might likewiſe poſſeſs the ſame quality; although the effects of the latter muſt ſurpaſs thoſe of the former in an aſtoniſhing degree. Flaſhes of lightning, he likewiſe obſerved, are generally ſeen crooked and waving in the air; and the electric ſpark drawn from an irregular body at ſome diſtance, and when it is drawn by an irregular body, or through a ſpace in which the beſt conductors are diſpoſed in an irregular manner, always exhibits the ſame appearance.

Lightning ſtrikes the higheſt and moſt pointed objects in its way, in preference to others; as high

hills [a], trees, ſpires, maſts, &c. and all pointed conductors receive and throw off the electric fluid more readily than thoſe which are terminated by flat ſurfaces. Lightning is obſerved to take the readieſt and beſt conductor; and this is the caſe with electricity in the diſcharge of the Leyden phial [b]; whence Dr. Franklin infers, that, in a thunder-ſtorm, it would be ſafer for a perſon to have his clothes wet than dry. Lightning burns, diſſolves metals, rends ſome bodies, ſtrikes people blind, deſtroys animal life, deprives magnets of their virtue, and reverſes their poles; and theſe are well-known properties of electricity.

Lightning not only gives polarity to the magnetic needle, but to all bodies that have any thing of iron in them, as brick, &c. and, by obſerving which way the poles of theſe bodies lie, it may be known, with the utmoſt certainty, in what direction the ſtroke paſſed. Signior Beccaria ſuppoſes, that perſons are ſometimes killed by lightning, without being really touched by it; a vacuum of air only being ſuddenly made near them, and the air ruſhing out of their lungs to ſupply it, and with ſo much violence that they could never recover their breath. In proof of this he alleges, that the lungs of ſuch perſons are found flaccid; whereas, when they are properly killed by the electric ſhock, the lungs are found inflated: but this hypotheſis is controverted by Dr. Prieſtley.

In order to demonſtrate, by actual experiment, the identity of the electric fluid with the matter of lightning, Dr. Franklin contrived to bring lightning from the heavens, by means of an electrical kite, which he raiſed, when a ſtorm of thunder was per-

a Feriunt ſummos
Fulmina montes. HORACE.

b This phial, and other phenomenons in electricity, are treated of in No. L.

ceived to be coming on; and, with the electricity thus obtained, he charged phials, kindled spirits, and performed all other electrical experiments, which are usually exhibited by an excited globe or tube. This happened in 1752, a month after the electricians in France, pursuing the method which he had proposed, had verified the same theory; but without any knowledge of what they had done. In 1753, he further discovered, that the air was sometimes electrified positively, and sometimes negatively; and that the clouds would change from positive to negative electricity several times in the course of one thunder-gust. He soon perceived, that this important discovery was capable of being applied to practical use; and he proposed a method, which he soon accomplished, of securing buildings from being damaged by lightning, by means of conductors; the use of which is now universally prevalent.

That the electric matter, which forms and animates the thunder-clouds, issues from places far below the surface of the earth, and that it buries itself there, is probable from the deep holes which have, in many places, been made by lightning; and from the flashes which have been seen to rise from wells and subterraneous cavities; as well as from the inundations accompanying thunder-storms, and occasioned by water bursting out of the bowels of the earth.—But the limits to which I am confined will not permit me to recapitulate all the inquiries and reasonings to which the various wonderful phenomenons of lightning and thunder have given rise: I shall, therefore, proceed to a few observations, which respect the safety of persons that are exposed to the perils of a thunder-storm.

Dr. Franklin advises those who are apprehensive of danger from lightning, to be in the middle of a room (provided it be not under a metal lustre suspended by a chain) sitting on one chair, and laying

their feet on another. It is ſtill ſafer, he ſays, to bring two or three mattreſſes, or beds, into the middle of the room, and folding them double, to place the chairs upon them; for, as they are not ſuch good conductors as the walls, the lightning will not chooſe to paſs through them: but the ſafeſt place of all is in a hammock, hung with ſilken cords, at an equal diſtance from all the ſides of a room. Dr. Prieſtley obſerves, that the place of moſt abſolute ſafety muſt be the cellar, and eſpecially the middle of it; for when a perſon is lower than the ſurface of the earth, the lightning muſt ſtrike the earth before it can poſſibly reach him. In the fields, the place of ſafety is within a few yards of a tree, but not quite near it. Neverthleſs, ſignior Beccaria cautions perſons not to depend on the neighbourhood of a higher, or, in all caſes, a better conductor than their own body; ſince, according to his repeated obſervations, the lightning by no means deſcends in one undivided track; but bodies of various kinds conduct their ſhare of it at the ſame time, in proportion to their quantity and conducting power [a].

Among the awful phenomenons of Nature, none have excited more terror than lightning and thunder. Some of the profligate Roman emperors, of whom hiſtory records that they procured themſelves to be deified, confeſſed, by their trembling and hiding themſelves, when they heard the thunder, that there was a Divine Power greater than their own—*cœlo*

[a] Earl Stanhope, in his Principles of Electricity, written when he was lord Mahon, obſerves, that damage may be done by lightning, not only by the main ſtroke and lateral exploſion, but likewiſe by that which he calls the returning ſtroke; that is, by the ſudden violent return of that part of the natural ſhare of electricity of any conducting body, or any combination of conducting bodies, which had been gradually expelled from ſuch body or bodies reſpectively, by the ſuperinduced elaſtic electrical preſſure of a thunder cloud's electrical atmoſpheres. See further on this ſubject, Franklin's Letters, Prieſtley's Hiſt. of Electricity, &c.

tonantem Jovem[a]. The greateſt ſecurity againſt the *terrors* of a thunder-ſtorm, although no certain one againſt its *effects*, is that life of piety and virtue which is the beſt guardian of every earthly bleſſing. The good man, who knows that every event is under the direction of an over-ruling Providence, and that this life is only a part of his exiſtence, introductory to the bliſsful ſcenes of immortality, will behold the terrors of the ſtorm with unſhaken reſolution; grateful to the Supreme Being if permitted to eſcape from the danger; and acquieſcing in the Divine Will, if thus to be conveyed, by an eaſy and inſtantaneous paſſage, to that heaven where his converſation had long been, and to that God with whom he delighted to walk.

Theſe ſentiments are beautifully expreſſed in the following lines, written in a midnight thunder-ſtorm, by the celebrated Mrs. Carter, and addreſſed to a lady:

Let coward Guilt with pallid Fear,
  To ſhelt'ring caverns fly,
And juſtly dread the vengeful fate,
  That thunders thro' the ſky.

Protected by that Hand, whoſe law
  The threat'ning ſtorms obey,
Intrepid Virtue ſmiles ſecure,
  As in the blaze of day.

[a] Horace. The ancient Romans gave the appellation of *Tonans*, the Thunderer, to Jupiter, their ſupreme deity; and emperor Auguſtus conſecrated a temple to Jupiter the Thunderer, on account of his deliverance from a great danger to which he had been expoſed in his Cantabrian expedition; when travelling by night, the vehicle in which he was carried was ſcorched by lightning, and a ſlave that bore his torch, inſtantly killed. Tonanti Jovi ædem conſecravit, liberatus periculo, cum expeditione Cantabrica per nocturnum iter lecticam ejus fulgor perſtrinxiſſet, ſervumque prælucentem exanimaſſet. Sueton. Octav. 29. And the poet Lucan adduces the thunder as a convincing proof, that Jupiter was the ſole ruler of the ſkies:

Per fulmina tantum
Sciret adhuc ſolum cœlo regnare Tonantem. Pharſ. lib. iii.

Jove's thunder will convince them of his reign. Rowe.

In the thick cloud's tremendous gloom,
The lightnings lurid glare,
It views the ſame All-gracious Pow'r,
That breathes the vernal air.

Thro' Nature's ever-varying ſcene,
By diff'rent ways purſu'd,
The one eternal end of Heav'n
Is univerſal good.

The ſame unchanging Mercy rules
When flaming ether glows,
As when it tunes the linnet's voice,
Or bluſhes in the roſe.

By Reaſon taught to ſcorn thoſe fears
That vulgar minds moleſt;
Let no fantaſtic terrors break
My dear Narciſſa's reſt.

Thy life may all the tend'reſt care
Of Providence defend;
And delegated angels round
Their guardian wings extend.

When, thro' creation's vaſt expanſe,
The laſt dread thunders roll,
Untune the concord of the ſpheres,
And ſhake the riſing ſoul;

Unmov'd mayſt thou the final ſtorm,
Of jarring worlds ſurvey,
That uſhers in the glad ſerene
Of everlaſting day.

L. ON ELECTRICITY.

Cauſa latet, vis eſt notiſſima. OVID.

The cauſe is ſecret, but th' effect is known.
ADDISON.

THE phenomenons of Electricity are ſo various, ſo brilliant, and ſo remote from the appearances under which natural bodies are commonly preſented to our obſervation, that while they amuſe the ſuperficial, and excite the attention of the moſt incurious obſerver, they are adapted to exerciſe the faculties of the moſt intelligent philoſopher, in the inveſtigation of their cauſes and relations. The number and variety of the experiments which have been made in this branch of philoſophy, within our own times, is aſtoniſhing. The ſcarcity of obſervations made in the preceding ages, and even by our immediate predeceſſors, on a ſubject which has proved ſo fruitful in our hands, is almoſt equally ſurpriſing. From the time of Thales the Mileſian, who flouriſhed about 640 years before Chriſt, and Theophraſtus, the diſciple of Ariſtotle, who lived about 300 years after, down to the middle of the ſeventeenth century, all that had been ſaid, or that was known of electricity, might be contained within the compaſs of a primer. Even the more modern writers of general ſyſtems of natural philoſophy either neglected it, or thruſt the little which they had to ſay concerning it into ſome obſcure corner of their work, and under other articles; not deeming it of ſufficient importance to give it a ſeparate place. Since the year 1720, however, various intereſting and important phenomenons have been obſerved; and theſe have

given riſe to a variety of reaſonings and theories. The extenſiveneſs, moreover, of this branch of knowledge, with regard to the relation which it now bears to many of the other ſciences, is not leſs worthy of obſervation. Down to the times even of Boyle and Newton, electricity has been ſolely employed in attracting and repelling ſtraws and chaff: in our days it has extended its influence even into the atmoſpheric regions, and has formed connections with almoſt every branch of natural philoſophy. It has even ſoared ſo high as to court an alliance with phyſical aſtronomy, and has had the confidence even to put in a claim, which may perhaps one day be allowed, of having a ſhare in the production of ſome of the grandeſt phenomenons of Nature.

The term *electricity* is derived from ἤλεκτρον, the Greek name for *amber*; a yellow tranſparent ſubſtance which has been very anciently obſerved to poſſeſs, when rubbed, the property of attracting light bodies; inſomuch that Thales of Miletus concluded hence, that it was animated[a]. The term *electricity* is now applied, not only to the power of attracting light bodies inherent in amber, but to other ſimilar powers, and their various effects, in whatever bodies they reſide, or to whatever bodies they may be communicated.—In a word, by *electricity* or *electrical force*, is underſtood, not only that power or property, which the ancients obſerved in amber and the lyncurius lapis, or tourmalin, but which agate, jet, ſealingwax, glaſs, and a variety of other ſubſtances, called *electrics*[b], are now known to

[a] Amber is alſo brought, by friction, to yield light pretty copiouſly in the dark; and hence it is reckoned among the native *phoſphori*.

[b] *Electrics* are thoſe ſubſtances, in which the electric fluid is capable of being excited, and accumulated, without tranſmitting it, and therefore called *non-conductors*, in oppoſition to *conductors*, which are called *non-electrics*. The electrics are likewiſe called *electrics per ſe*, and *original electrics*. They are capable of being excited, ſo as to exhibit the electrical appearances of attracting and repelling light bodies, emitting

possess, of attracting light bodies, &c. when excited by heat or friction; and which is also capable of being communicated, in particular circumstances, to other bodies: and the science of electricity is that part of natural philosophy, which proposes to investigate the nature and effects of this power, and of other similar powers connected with it.

Thus we find, that electricity was indebted to the ancients for little more than its name, which it still retains, and which, although very inadequate to the present state of this branch of knowledge, was sufficiently expressive of the little which they knew concerning it. The father of modern electricity appears to have been Dr. Gilbert, author of an excellent treatise, *De Magnete*, published in 1600, who greatly augmented the list of electrical bodies. This was increased about a century afterward, by Mr. Boyle, who observed some new circumstances concerning electrical attraction. His contemporary, Otto Guericke, the celebrated inventor of the air-pump, first took notice of the mutual repulsion of bodies electrified, and of the light and sound exhibited by excited electrics. The illustrious Newton was content with a few experiments, from which it appeared, that excited glass attracted light bodies on the side opposite to that on which it was rubbed. In 1709, Mr. Hawksbee, by means of his glass globes, as well as those of sealingwax and resin, observed many new and striking phenomenons. Mr. Grey, about twenty years after, first discovered, that the electric virtue might be communicated from excited electrics to non-electrics in contact with them. To

a spark of light, attended by a snapping noise, and yielding a current of air, the sensation of which resembles that of a spider's web drawn over the face, and a smell like that of phosphorus, either by friction, or by heating and cooling, or by melting, and pouring one melted substance into another. *Conductors* denote those substances, which are capable of receiving and transmitting the electric virtue. These terms were first introduced by Dr. Desaguliers.

him, likewiſe, and to his friend Mr Wheeler, we are indebted for the important diſcovery of inſulating bodies, by which the electricity communicated to them is detained and preſerved, and which laid the foundation of almoſt all the ſubſequent diſcoveries. M. du Fay next made a capital diſcovery; that of the two ſpecies of electricity, which he denominated the vitreous and reſinous, from the principal ſubſtances to which they reſpectively belong: the characteriſtic of which two kinds is, that bodies, poſſeſſed of one of them, repel all other bodies, whoſe electricity is of the ſame ſpecies with their own, and attract all bodies poſſeſſed of the other ſpecies. M. du Fay alſo, accompanied by abbè Nollet, firſt perceived the electric ſpark; and the abbè declares that he ſhall never forget the ſurpriſe excited both in M. du Fay and himſelf, by the firſt electrical ſpark that was ever drawn from the human body. In Mr. Grey's experiments, ſubſequent to this, we find the origin of metallic inſulated conductors, and the firſt obſervation of the pencil of rays perceived at their pointed extremities.

Electricity, however, did not make any rapid progreſs till after the year 1743, when the uſe of globes was again introduced by the German philoſophers; tubes only, after the time of Hawkſbee, being made uſe of in electrical experiments. By the ſize and number of their globes, the Germans excited a prodigious power of electricity. The ſtrength of the ſimple electric ſparks was increaſed to ſuch a degree, that they were felt from a man's head to his foot, and ſmall birds were killed by them. But the moſt ſurpriſing effect produced by the German machines, was the acceſſion of inflammable bodies by the electric ſpark, in 1744, by Dr. Ludolf of Berlin, who kindled, by its means, the vitriolic ether. Dr. Watſon, in England, about this period, fired ſpirits conſiderably diluted, diſtilled vegetable oils,

resinous substances, and gunpowder. He set fire to the factitious air produced by the solution of iron in diluted spirit of vitriol, which when it did not find a ready passage out of the mouth of the flask in which it was contained, was kindled throughout its whole capacity, with an explosion equal to that of a large pistol. He likewise fired spirit of wine by a drop of cold water, and afterward even by ice.

But the most amazing of all the electrical discoveries was the Leyden phial, so called from the place in which it was made, in 1746, by Mr. Cuneus, as he was repeating some experiments of messieurs Muschenbroeck and Allamand; or, as others say, by Mr. Muschenbroeck himself, who first felt the shock as he was using an iron cannon, suspended on silk lines, for a conductor. Dr. Priestley, in his History of Electricity, gives an account of the descriptions which those who first felt the electric shock, gave of it, while they were under the influence of the panic it occasioned. "Mr. Muschenbroeck (says he) who tried the experiment with a very thin glass bowl, says, in a letter to M. Reaumur, which he wrote soon after the experiment, that he felt himself struck in his arms, shoulders, and breast, so that he lost his breath, and was two days before he recovered from the effects of the blow and the terror. He adds, that he would not take a second shock for the kingdom of France".—Other electricians have described the same terrors; and their descriptions, in the present advanced state of electricity, may appear exaggerated. But we may, in some measure, account for this, by considering that they were under the influence of the surprise and terror excited by a *new* and *unexpected* feeling, of a very peculiar kind, produced by a seemingly inadequate cause, lurking in a tumbler of water. The sensation caused by the electric shock is indeed, a perfect *unique*; and every change or

commotion perceived in the body for ſome time after the ſhock thus circumſtanced, might be attributed naturally enough by a timorous perſon, although ever ſo well acquainted with the phenomenons of electricity already known, or the laws already eſtabliſhed, to ſome ſecret and unaccountable operations of this inviſible and myſterious agent; part of which, on this new and ſtrange modification of it, might be ſuſpected, on its diſlodgment from the tumbler, to have only changed its quarters, and to be ſtill lying in ambuſh, and playing its pranks with the body; or, at leaſt, to have *permanently* diſcompoſed and ruffled ſome of the fibres, in its rapid paſſage through it. Even at this day, the marvellous air of this experiment is not ſo far diminiſhed by frequent repetitions, but that it ſtill throws a ſimilar deluſion on many; who are thereby induced to think that they feel the effects of the electric ſhock for ſome time after it has been given; and few receive it without ſome degree of perturbation.—It was this aſtoniſhing experiment, Dr. Prieſtley obſerves, that gave an eclat to electricity. Every body was eager to ſee, and, notwithſtanding the terrible account that was reported of it, to feel the ſenſation produced by it. It is to this day juſtly viewed with aſtoniſhment by the moſt profound electricians: for though ſome remarkable phenomenons of it have been excellently accounted for by Dr. Franklin, and others, ſtill much remains to be done, and, in many reſpects, the circumſtances attending it are ſtill inexplicable.

In 1747, Dr. Watſon made a variety of noble experiments, with a view of aſcertaining the diſtance to which the electric ſhock could be carried, and the velocity with which it moves. In the firſt of theſe, the ſhock was given, and ſpirits kindled, by electric fire which had been conveyed through the Thames. In a ſubſequent experiment, the ſenſible inſtantaneity of the motion of the electric fluid was directly aſcer-

tained by an obſerver, who, though in the ſame room with the charged phial, was at the ſame time in the middle of an electric circuit of two miles, and *felt* himſelf ſhocked, at the ſame inſtant that he *ſaw* the phial diſcharged. Another important diſcovery by Dr. Watſon was, that the glaſs globes and tubes did not contain within themſelves the electric fluid which appeared on their excitation, but drew it from the earth and the bodies contiguous to the rubber, and in contact with it. Mr. Wilſon appears to have made the ſame obſervation. Dr. Watſon likewiſe diſcovered, what Dr. Franklin had obſerved about the ſame time in America, the *plus* and *minus* ſtates of electrified bodies.

This ſimple principle of the *plus* and *minus*, or the *poſitive* and *negative* ſtates of the electric matter in bodies, became, in the hands of Dr. Franklin, as fruitful (if we make allowance for the different nature and importance of the ſubject) as the principle of univerſal attraction in thoſe of Newton. By the application of it, the Leyden phial, which had hitherto teemed with myſtery and contradiction, had its moſt glaring inconſiſtencies reconciled and accounted for in the moſt ſimple manner. The doctor ſhowed, that in the act of electrization, one ſide of the phial (the inſide, for inſtance) was electrified *poſitively*; that is, had an additional quantity of the electric fluid thrown upon it; and that the other ſide was electrified *negatively*; that is, was deprived of an equal quantity; and that the effect of that operation was not an increaſe of the quantity of electric fire in the phial, but ſolely a change produced in the ſituation of the *natural quantity* of electric matter belonging to it.

Dr. Franklin's important diſcovery of the identity of lightning, and the electric fire, I mentioned in my laſt paper. This is one of the few capital diſcoveries in electricity, for which we are not at all

indebted to chance, but to one of thoſe bold and happy ſtretches of thought, in conſequence of which thoſe gigantic ſtrides are made in ſcience, which diſtinguiſh geniuſes of a ſuperior order. By this intereſting and important diſcovery (the greateſt, perhaps, that has been made in the whole compaſs of philoſophy ſince the time of ſir Iſaac Newton) we have it now in our power, by a ſimple and cheap apparatus, to direct the courſe of the hitherto *inevitable fulmen*, and thereby, with reſpect to buildings at leaſt, to deprive it of its power of hurting. By what ſimple and ſlender inſtruments, even the playthings of children, does the hand of Genius extort from Nature her choiceſt ſecrets. Thus Newton, by means of a ſoap-bubble, inveſtigates the magnitude of the component particles of bodies, on which their colour depends; and Franklin, by raiſing a kite, diſcovers the nature of lightning!

The laſt great diſcovery of which I ſhall take notice (and to which Mr. Canton led the way) is that of a new and very extenſive principle in electricity, by meſſieurs Wilke and Æpinus, two foreign electricians. The principle, which, indeed, is founded on Dr. Franklin's theory of poſitive and negative electricity, is this; that the electric fluid, when there is a redundancy of it in any body, repels the electric fluid in any other body, within its influence, and drives it into the remote parts, or quite out of the body, if there be any outlet for that purpoſe; thereby reducing the body to a ſtate contrary to its own; that is, a negative ſtate. On this principle they undertook to charge *a plate of air*, like a plate of glaſs, and thereby to imitate, in the moſt perfect manner, the phenomenon of lightning. They ſucceeded, by ſuſpending two large boards of wood covered with tin, with the flat ſides parallel to one another, and ſome inches aſunder. On electrifying *poſitively* one of the boards (which may be conſidered

as metallic coatings to the two ſurfaces of the aërial plate) the other board became electrified *negatively*; and a perſon, touching this laſt with one hand, and bringing his other to the other board, received a ſhock through his body, as in the Leyden experiment.—With this plate of air they made a variety of curious experiments. The two metal plates being in oppoſite ſtates, ſtrongly attracted each other, and would have ruſhed together, if they had not been kept aſunder by ſtrings. Sometimes, the electricity of both would be diſcharged by a ſtrong ſpark between them, as when a plate of glaſs burſts, and is perforated by too great a charge. A finger put between them promoted the diſcharge and felt the ſhock. If an eminence were made on either of the plates, the ſelf-diſcharge would always be made through it; and a pointed body fixed upon either of them prevented their being charged at all.

The ſtate of theſe two plates, they excellently obſerved, juſtly repreſents the ſtate of the clouds during a thunder-ſtorm; the clouds being always in one ſtate and the earth in the oppoſite; while the body of air between them anſwers the ſame purpoſe as the ſmall plate of air between the boards, or the plate of glaſs between the two metal coatings of the Leyden phial. The phenomenon of lightning is the burſting of the plate of air by a ſpontaneous diſcharge, which is always made through eminencies, and the bodies through which the diſcharge is made are violently ſhocked.

With reſpect to the nature of the electric fluid, philoſophers have entertained very different ſentiments. Mr. Wilſon, and others, have ſuppoſed it to be the ſame with the ether of ſir Iſaac Newton; but Dr. Prieſtley is of opinion, that the electric matter is either phlogiſton, or contains it. Perhaps we may be allowed to enlarge our views, and conſider the ſun as the fountain of the electric fluid;

and the zodaical light, the tails of comets, the aurora borealis, lightning, and artificial electricity, to be its various and not very diſſimilar modifications.—But it cannot be expected, in the contracted ſpace to which I am confined, that I can enlarge further on this ſcience; a ſcience on which ſo many volumes have been written. I have been obliged to treat the ſubject in a general light; as exhibiting a matter of curious ſpeculation, to obſerve the ignorance of the greateſt men, for ſo many ages, concerning phenomenons, with which no man of letters is now unacquainted. It is no leſs entertaining and inſtructive to obſerve, that even after ſome light had been thrown upon the ſubject, it required the efforts of ingenious men, for near a century more, to bring the ſcience to its preſent advanced ſtate; that, however, ſo far from having reached perfection, the myſteries of Nature are ſo profound, that there are ſtill many deſiderata to be known, ſtill ſufficient to perplex the moſt intelligent philoſopher, and to induce him to ſuſpect, while he looks back with the exultation of ſuperiority, at the ignorance of the ancients, and even of the illuſtrious ſages of the ſeventeenth century, with reſpect to the preſent moſt obvious principles of the ſcience, that *we* may appear like children to the philoſophers of another age, whom new phenomenons, new principles, and perhaps a new theory, may aſtoniſh; while, impreſſed with a more awful and religious ſenſe of the wonderful operations of the Deity, they may exclaim in the language of the celeſtial choir, "Hallelujah, for the Lord God Omnipotent reigneth".

LI. ON THE AURORA BOREALIS, AND OTHER FIERY METEORS.

Silent from the north
A blaze of meteors ſhoots : enſweeping firſt
The lower ſkies, they all at once converge
High to the crown of heaven, and all at once,
Relapſing quick, as quickly reaſcend,
And mix, and thwart, extinguiſh, and renew,
All ether courſing in a maze of light. THOMSON.

THE Aurora Borealis, or Northern Lights, is a kind of meteor appearing in the northern part of the heavens, moſtly in the winter time, and in froſty weather. It is now ſo generally known, that no deſcription is requiſite of the appearance which it uſually makes in this country. But it is in the arctic regions that it appears to perfection, particularly during the ſolſtice. In England, the extremities only of theſe northern lights are to be ſeen, that we have but a faint idea of their ſplendour and their motions [a]. According to the ſtate of the atmoſphere, they differ in colours. They often aſſume the colour of blood, and make a very dreadful appearance. The ruſtic ſages become prophetic, and terrify the gazing ſpectators with the dread of war, peſtilence, and famine. This ſuperſtition was not peculiar to

[a] Of the Aurora Borealis in Shetland, Siberia, and Hudſon's Bay, and its beneficial effects in the polar regions in general, ſee No. v, On Winter in the Polar Regions.

By dancing meteors then, that ceaſeleſs ſhake
A waving blaze refracted o'er the heavens,
And vivid moons, and ſtars that keener play
With double luſtre from the gloſſy waſte,
Ev'n in the depth of polar night, they find
A wondrous day: enough to light the chace,
Or guide their daring ſteps to Finland-fairs. THOMSON.

the northern iſlands; nor are theſe appearances of recent date. The ancients called them *chaſmata*, *trabes*, and *bolides*, according to their forms or colours. But, in old times, they were extremely rare, and, on that account, were the more taken notice of. From the days of Plutarch to thoſe of our ſage hiſtorian ſir Richard Baker, they were ſuppoſed to be portentous of great events, and timid imaginations ſhaped them into aërial conflicts:

From look to look, contagious through the crowd,
The panic runs, and into wondrous ſhapes
Th' appearance throws: Armies in meet array,
Throng'd with aërial ſpears and ſteeds of fire;
Till the long lines of full-extended war
In bleeding fight commixt, the ſanguine flood
Rolls a broad ſlaughter o'er the plains of heaven.
As thus they ſcan the viſionary ſcene,
On all ſides ſwells the ſuperſtitious din,
Incontinent; and buſy Frenzy talks
Of blood and battle; cities overturn'd,
And late at night in ſwallowing earthquake ſunk,
Or hideous wrapt in fierce aſcending flame;
Of ſallow famine, inundation, ſtorm;
Of peſtilence, and every great diſtreſs;
Empires ſubvers'd, when ruling Fate has ſtruck
Th' unalterable hour: ev'n Nature's ſelf
Is deem'd to totter on the brink of time.
Not ſo the man of philoſophic eye,
And inſpect ſage; the waving brightneſs he
Curious ſurveys, inquiſitive to know
The cauſes, and materials, yet unfix'd,
Of this appearance beautiful and new. THOMSON.

The only thing that reſembles a diſtinct hiſtory of this phenomenon, is what we have from the learned Dr. Halley, in the Philoſophical Tranſactions, No. 347. The firſt account he gives, is of the appearance of what the author calls *burning ſpears*, and which was ſeen at London in 1560. This

account is taken from a book entitled, A Deſcription of Meteors, by W. F. *D. D.* and reprinted at London in 1654. The next appearance, on the teſtimony of Stow, was in October 1564. In 1574 alſo, according to Camden and Stow, an aurora borealis was obſerved two nights ſucceſſively. Two were ſeen, at different times, in the year following, in Brabant. They were compared, by Cornelius Gemma, to ſpears, fortified cities, and armies fighting in the air. Michael Mæſtlin, tutor to the great Kepler, aſſures us, that, in the county of Wurtemberg in Germany, theſe phenomenons, which he calls *chaſmata*, were ſeen by himſelf, no leſs than ſeven times, in 1580. In 1581, they appeared in an extraordinary manner in April and September, and in a leſs degree at ſome other times of the ſame year. In September 1621, this phenomenon was obſerved all over France, and deſcribed by Gaſſendus, who gave it the name of *aurora borealis*; yet neither this, nor any ſimilar appearances poſterior to 1574, are deſcribed by Engliſh writers till the year 1707; which, as Dr. Halley obſerves, ſhows the great neglect of curious matters which at that time prevailed. From 1621, indeed, to 1707, there is no mention of an aurora borealis having been ſeen by any perſon, either in England or foreign countries; and, conſidering the number of aſtronomers, who, during that period, were almoſt conſtantly obſerving the heavens, we may reaſonably conclude, that no ſuch phenomenon appeared till after an interval of eighty-ſix years. In 1707, a ſmall one was ſeen in November; and during that year and the next, the ſame appearances were repeated five times. The next on record is that mentioned by Dr. Halley, as appearing on March 6, 1716. The ſplendour of this attracted univerſal attention. By the vulgar it was viewed with conſternation; and they conſidered it as marking the introduction of a

foreign race of princes into this country[a]. Since that time, theſe meteors have been ſo common, that no account has been kept of them.

It was for a long time a doubt whether this meteor appeared only in the northern hemiſphere, or whether it were to be obſerved alſo near the ſouth pole. This is now aſcertained by Mr. Forſter, who, in his Voyage round the World with captain Cook, aſſures us, that he obſerved it in the high ſouthern latitudes, although with appearances ſomewhat different from thoſe which are ſeen here. "On the 17th of February 1773 (ſays Mr. Forſter) as we were in latitude 58° ſouth, a beautiful phenomenon was obſerved during the preceding night, which appeared again ſeveral following nights. It conſiſted of long columns of a clear white light, ſhooting up from the horizon to the eaſtward, almoſt to the zenith, and gradually ſpreading on the whole ſouthern part of the ſky. Theſe columns were ſometimes bent ſidewiſe at their upper extremities; and, although in moſt reſpects ſimilar to the northern lights of our hemiſphere, yet differed from them in being always of a whitiſh colour; whereas ours aſſume various tints, eſpecially thoſe of a fiery and purple hue. The ſky was generally clear when they appeared, and the air ſharp and cold, the thermometer ſtanding at the freezing point".

I ſhall not attempt to give any account of the earlier conjectures concerning the cauſe of this phenomenon. It will be ſufficient to obſerve, that ever ſince the identity of lightning, and of the electric matter, has been aſcertained, philoſophers have been

[a] Dr. Halley obſerved, that this aurora borealis roſe to a prodigious height, it being ſeen from the weſt of Ireland to the confines of Ruſſia and Poland on the eaſt; nor did he know how much further it might be viſible; ſo that it extended at leaſt 30° in longitude, and from latitude 50° north it was ſeen over all the northern parts of Europe; and, in all the places where it was viſible, the ſame appearances were exhibited, which Dr. Halley obſerved in London.

naturally led to ſeek the explication of aërial meteors in the principles of electricity; and there is now no doubt, but that the greater part of them, and eſpecially the aurora borealis, are electrical phenomenons. Beſide the more obvious and known appearances which conſtitute a reſemblance between this meteor and the electric matter by which lightning is produced, it has been obſerved, that the aurora borealis produces a very ſenſible fluctuation in the magnetic needle; and that, when it has extended lower than uſual into the atmoſphere, the flaſhes have been attended with various ſounds of rumbling and hiſſing, taken notice of both by ſignior Beccaria and M. Meſſier. But I have, in ſome meaſure, anticipated this part of my ſubject, in my paper On Comets [a], to which I refer my readers for the ſentiments of Dr. Hamilton and abbé Mann, who have each produced the moſt ſatisfactory arguments to demonſtrate the identity of the matter that forms the tail of comets, the aurora borealis, and the electric fluid. Dr. Blagden has alſo given a copious illuſtration of this ſubject in his account of ſome fiery meteors, which appeared in 1783 [b].

Of the aurora borealis I have one more obſervation to make of great importance to ſeamen. In 1772, Mr. Winn preſented a paper to the Royal Society, in which he ſays, that the appearance of an aurora borealis is a certain ſign of a hard gale of wind from the ſouth or ſouthweſt. This he never found to fail in twenty-three inſtances; and he even thinks, that from the ſplendour of the meteor, ſome judgement may be formed concerning the enſuing tempeſt. If the aurora be very bright, the gale will come on within twenty-four hours, but will be of no long duration: if the light be faint and dull, the gale will be leſs violent, and longer in coming on,

[a] No. VIII. [b] Phil. Tranſ. vol. lxxiv, part i.

but will alſo laſt longer. His obſervations were made in the Engliſh Channel, where ſuch winds are very dangerous; and, by attending to the aurora, he ſays he often got eaſily out of it, when others narrowly eſcaped being wrecked [a].

There are other fiery meteors beſide lightning and aurora borealis; ſuch as *fiery globes*, moving at prodigious heights, with incredible velocity [b]; the *ignis fatuus*, *draco volans*, *falling ſtars*, &c.

The Ignis Fatuus is a common meteor, chiefly ſeen in dark nights, frequenting meadows, marſhes, and other moiſt places, and often ſeen in burying-grounds, and near dunghills. It is known among the common people by the name of Will with a Wiſp, and Jack with a Lanthorn. The form and ſize of theſe *ignes fatui* are very various. The late experiments on air ſerve to furniſh a rational explication of this phenomenon, to which the ignorant and ſuperſtitious have aſcribed ſo many alarming purpoſes. Inflammable air has been found to be the moſt common of all the factitious airs in nature; and to be the uſual product of the putrefaction and decompoſition of vegetable ſubſtances in water; and ſignior Volta, in a letter to Dr. Prieſtley, informs him, that he fires inflammable air by the electric ſpark, even when the electricity is very moderate; and he ſuppoſes, that this experiment explains the inflammation of the ignis fatuus, provided it conſiſts of inflammable air iſſuing from marſhy ground by the help of the electricity of fogs, and by *falling ſtars*, which are very probably thought to have an electric origin [c]. Dr. Shaw deſcribes an ignis fatuus, which he ſaw in Paleſtine, that was ſometimes globular, or in the form of the flame of a candle; and immedi-

[a] Phil. Tranſ. vol. lxiv, part i.

[b] For a deſcription of theſe fiery globes, I muſt refer to Dr. Blagden's account abovementioned.

[c] Prieſtley's Obſervations on Air, vol. iii, page 382.

ately after ſpread itſelf ſo much as to involve the whole company in a pale inoffenſive light, and then contract itſelf again, and ſuddenly diſappear. But in leſs than a minute it would become viſible as before; or, running along from one place to another, with a ſwift progreſſive motion, would expand itſelf, at certain intervals, over more than two or three acres of the adjacent mountains. The atmoſphere, at this time, had been thick and hazy, and the dew on their bridles was unuſually clammy and unctuous. —In the ſame weather, he obſerved thoſe luminous appearances, which, at ſea, ſkip about the maſts and yards of ſhips, and which the ſailors call *corpuſanſe*, by a corruption of the Spaniſh word *cuerpoſanto* [a].

The Draco Volans is a fat, heterogeneous, earthy meteor, appearing long and ſinuous, ſomething in the ſhape of a *flying dragon*. It is generally ſeen on the banks of rivers and in marſhy places, and ſeldom riſes very high from the ground, but plays and dances about the ſurface in an agreeable manner; and if people go up to it, it will ſtick to their hands and clothes, without burning, or doing them any injury. They are more common in the ſummer months than in the winter, and are more frequently ſeen in thick weather than in clear.

A Falling Star is a meteor, the explication of which has puzzled all philoſophers, till our modern diſcoveries in electricity have led to the moſt probable account of it. Signior Beccaria makes it pretty evident that it is an electrical appearance [b].

To the ignis fatuus, and other fiery meteors, which are viſible near the earth, Thomſon has thus alluded in his Autumn:

Now black, and deep, the night begins to fall,
A ſhade immenſe. Sunk in the quenching gloom,

[a] Shaw's Travels, p. 363. [b] Prieſtley's Elect. vol. i, p. 434.

Magnificent and vaſt, are heaven and earth.
Order confounded lies; all beauty void;
Diſtinction loſt; and gay variety
One univerſal blot: ſuch the fair power
Of light, to kindle and create the whole.
Drear is the ſtate of the benighted wretch,
Who then, bewilder'd, wanders through the dark,
Full of pale fancies, and chimeras huge;
Nor viſited by one directive ray,
From cottage ſtreaming, or from airy hall.
Perhaps, impatient as he ſtumbles on,
Struck from the root of ſlimy ruſhes, blue,
The wild-fire ſcatters round, or gather'd trails
A length of flame deceitful o'er the moſs:
Whither decoy'd by the fantaſtic blaze,
Now loſt, and now renew'd, he ſinks abſorpt,
Rider and horſe, amid the miry gulf:
While ſtill, from day to day, his pining wife
And plaintive children his return await,
In wild conjecture loſt. At other times,
Sent by the *better Genius* of the night,
Innoxious, gleaming on the horſe's mane,
The meteor ſits; and ſhows the narrow path,
That winding leads through pits of death, or elſe
Inſtructs him how to take the dangerous ford.

LII. ON MAGNETISM AND THE MARINER'S COMPASS.

Almighty Cauſe! 'tis thy preſerving care,
That keeps thy works for ever freſh and fair:
Hence life acknowledges its Glorious Cauſe,
And matter owns its Great Diſpoſer's laws;
Hence flow the forms and properties of things;
Hence riſes harmony, and order ſprings.
Thy watchful providence o'er all intends;
Thy works obey their Great Creator's ends.
Thee, Infinite! what finite can explore?
Imagination ſinks beneath thy power.
Yet preſent to all ſenſe that power remains:
Reveal'd in Nature, Nature's Author reigns.

BOYSE.

ALTHOUGH the phenomenons of the magnet have, for many ages, engaged the attention of natural philoſophers, not only by their ſingularity and importance, but alſo by the obſcurity in which they are involved; yet very few additions have been made to the diſcoveries of the firſt inquirers into the ſubject. The powers of genius which have been hitherto employed in inveſtigating this ſubject, have not been able to frame a hypotheſis, that will account, in an eaſy and ſatisfactory manner, for all the various properties of the magnet, or to point out the links of the chain which connect it with the other phenomenons of the univerſe. It is certain, indeed, that both natural and artificial electricity will give polarity, or a direction to the poles of the earth, to needles, and even reverſe a given polarity; and hence it may be inferred, that there is a conſiderable affinity between the electric and magnetic fluid; but in what manner electricity acts in producing magnetiſm, is ſtill utterly unknown.

From the works of Hippocrates, Plato, and Ariſtotle, who each flouriſhed above three centuries before the chriſtian era, it is certain that the ancients were acquainted with the attractive and repulſive powers of the magnet; but it does not appear, that they knew of its tendency to the pole, or of the mariner's compaſs. Lucretius, in his ſixth book *De Rerum Naturâ*, has given a poetical diſſertation upon the attractive property of the magnet, but without the leaſt intimation of its polarity. To him, however, we are indebted for the origin of the term *magnet*:

Quod ſupereſt, agere incipiam, quo fœdere fiat
Naturæ, lapis hic ut ferrum ducere poſſit.
Quem magneta vocant patrio nomine Graii,
Magnetum quia ſit patriis in finibus ortus.

That is, " The magnet, of whoſe attractive virtues he intends to treat, is ſo called, by the Greeks, from Magneſia, a diſtrict of Lydia, in which it was firſt found". Ariſtotle, by way of excellence, calls it only λιθος, *the ſtone*. Pliny calls it *Heraclius lapis*, from the city of Heraclea, in the country of the Magnetes abovementioned. By the Italians it is called *calamita*, and by the French *aimant*. Our Engliſh name, the *loadſtone*, is of Saxon extraction.

As the ancients were not acquainted with the true method of philoſophiſing, and were content with obſervation alone, their knowledge of nature was very confined, and did not afford any conſiderable advantage to ſociety. Modern philoſophers, by combining experiment with obſervation, ſoon extended the boundaries of ſcience, and diſcovered the polarity of the magnet; a property which conſtitutes the baſis of navigation, and gives exiſtence to commerce.

The loadſtone, leading ſtone, or natural magnet, is a ferruginous ſtone, found in the bowels of the earth, generally in iron mines; of all forms and

ſizes, and of various colours. It is endowed with the property of attracting iron; and of both pointing itſelf, and alſo enabling a needle, touched upon it, and duly poiſed, to point toward the poles of the world.—Loadſtones, in general, are very hard and brittle; and, for the moſt part, more vigorous, in proportion to their degree of hardneſs. Conſiderable portions of iron may be extracted from them. Mr. Kirwan ſays, that the magnet ſeems to contain a ſmall quantity of ſulphur, and is often contaminaed with a mixture of quartz and argil. It is poſſible, it may contain nickel; for this, when purified to a certain degree, acquires the properties of a magnet; but its conſtitution has not hitherto been properly examined [a].

Artificial magnets, which are made of ſteel, are now generally uſed in preference to the natural magnet; not only, as they may be procured with greater eaſe, but becauſe they are far ſuperior to the natural magnet in ſtrength, communicate the magnetic virtue more powerfully, and may be varied in their form more eaſily. The natural magnet, in courſe, is now very little eſteemed, except as a curioſity.

The power of attracting iron, &c. poſſeſſed by the loadſtone, which is alſo communicable to iron and ſteel, is called *magnetiſm.* A rod or bar, of iron or ſteel, to which a permanent polarity has been communicated, is called a *magnet.* The points in the magnet which ſeem to poſſeſs the greateſt power, or in which the virtue ſeems to be concentrated, are termed the *poles of a magnet.* The *magnetical meridian* is a vertical circle in the heavens, which interſects the horizon, in the points to which the magnetical needle, when at reſt, is directed: its *axis* is a right line which paſſes from one pole to the other; and its *equator* is a line perpendicular to the axis of the magnet, and exactly between the two poles.

[a] Kirwan's Elements of Mineralogy, p. 271.

The diſtinguiſhing and characteriſtic properties of the magnet are, firſt, its attractive and repulſive powers; ſecondly, the force by which it places itſelf, when ſuſpended freely, in a certain direction toward the poles of the earth; thirdly, its dip or inclination toward a point below the horizon; and, fourthly, the property it poſſeſſes of communicating the foregoing powers to iron or ſteel.

It has been already obſerved, that the ancients do not ſeem to have been acquainted with the directive power of the magnet. Philoſophers were content, for many ages, with the knowledge of its attractive and repulſive qualities. But, about the beginning of the fourteenth century, when the ſpirit of exploring diſtant regions was gradually forming in Europe, a very fortunate diſcovery was made, which contributed more than all the ingenuity and efforts of preceding ages, to improve and to extend navigation. That wonderful property of the magnet, by which it communicates ſuch virtue to a needle or ſlender rod of iron, as to point toward the poles of the earth, was then firſt obſerved. The uſe which might be made of this in directing navigation was immediately perceived. That moſt valuable, but now familiar inſtrument, the Mariner's Compaſs, was invented. When navigators found, that by this inſtrument, they could, at all ſeaſons, and in every place, diſcover the north and ſouth with the greateſt eaſe and accuracy, it became no longer neceſſary to depend, like the voyagers of former ages [a], merely on the light of the ſtars, and the obſervation of the ſeacoaſt. They gradually abandoned their ancient timid and lingering courſe along the ſhore, ventured boldly into the ocean, and, relying on this new guide, could ſteer in the darkeſt night, and under the moſt cloudy ſky, with a ſecurity and preciſion

[a] See No. LVI, On the Art of Navigation.

till then unknown. The compaſs may be ſaid to have opened to man the dominion of the ſea, and to have put him in full poſſeſſion of the earth, by enabling him to viſit every part of it. Flavio Gioia, a citizen of Amalſi, a town of conſiderable trade in the kingdom of Naples, was the author of this diſcovery, about the year 1302. It has been often the fate of thoſe illuſtrious benefactors of mankind, who have enriched ſcience, and improved the arts, by their inventions, to derive more reputation than benefit from the happy efforts of their genius. But the lot of Gioia has been ſtill more cruel: through the inattention or ignorance of contemporary hiſtorians, he has been defrauded even of the fame to which he had ſo juſt a title. We receive no information from them reſpecting his profeſſion, his character, the preciſe time when he made this important diſcovery, or the accidents and inquiries which led to it. The knowledge of this event, though productive of greater effects than any recorded in the annals of the human race, is tranſmitted to us without any of thoſe circumſtances, which can gratify the curioſity it muſt naturally awaken [a].

[a] In this account of the diſcovery of the mariner's compaſs, I have adhered to the opinion of Dr. Robertſon, who, in his Hiſtory of America, vol. i, quotes, as his authority, Collinas et Trombellus de Acus Nauticæ Inventore. Inſtit. Acad. Bunon. tom. ii.—It may not be improper, however, to obſerve, that this great diſcovery has been referred to an earlier period. Marco Polo, a noble Venetian, and great traveller, is ſaid to have introduced the compaſs in 1260; but this is likewiſe ſaid not to have been his own invention, but borrowed from the Chineſe: while others aſſert, that the Chineſe knew nothing of the mariner's compaſs, till it was introduced into their country by the Europeans. *See Chambers' Cyclopædia, and Adams on Electricity.* —M. Perrault, in his Parallel between the Ancients and the Moderns, has cited ſome verſes of Guyot, of Provence, who wrote about the year 1180, from which one might be led to infer, that the uſe of the compaſs was then known in the ſouth of France: "There is (ſays he) a ſtar that never moves, and an art that never deceives, by the virtue of the compaſs, an ugly black ſtone, which always attracts iron".

But although the uſe of the compaſs might enable the Italians to perform the ſhort voyages to which they were accuſtomed, with greater ſecurity and expedition, its influence was not ſo ſudden or extenſive, as immediately to render navigation adventurous, and to excite a ſpirit of diſcovery. Many cauſes combined to prevent this beneficial invention from producing its full effect immediately. Men relinquiſh ancient habits ſlowly and reluctantly: they are averſe to new experiments, and venture upon them with timidity. The commercial jealouſy of the Italians, it is probable, laboured to conceal the happy diſcovery of their countryman from other nations. The art of ſteering by the compaſs with ſuch ſkill and accuracy as to inſpire a full confidence in its direction, was acquired progreſſively. Sailors, unaccuſtomed to loſe ſight of land, durſt not launch out at once, and commit themſelves to unknown ſeas. Accordingly, near half a century elapſed, from the time of Gioia's diſcovery, before navigators ventured into any ſeas which they had not been accuſtomed to frequent. But, in the courſe of the fifteenth century, diſcoveries were made far beyond the conception of all former ages. It is worthy of note, however, that there is a paſſage in the Medea of Seneca, to which theſe very diſcoveries might almoſt ſeem to give the importance of a prediction:

Venient annis
Secula ſeris, quibus oceanus
Vincula rerum laxet, et ingens
Pateat tellus, Tiphyſque novos
Deteget orbes.

In ages yet to come,
Another Tiphys may new ſeas explore,
And worlds diſcover never known before.

It is remarkable, that in the firſt voyage of Columbus, in the year 1492, when his little fleet was

above 200 leagues to the weſt of the Canary Iſles, the Spaniards were ſtruck with an appearance no leſs aſtoniſhing than new. They obſerved that the magnetic needle, in their compaſſes, did not point exactly to the polar ſtar, but varied toward the weſt; and, as they proceeded, this variation increaſed. This appearance, which is now familiar, although it ſtill remains one of the myſteries of nature, into the cauſe of which the ſagacity of man has not yet been able to penetrate, filled the companions of Columbus with terror. They were then in a boundleſs unknown ocean, far from the uſual courſe of navigation: nature itſelf ſeemed to be altered; and the only guide which they had left ſeemed about to fail them. Columbus, with equal quickneſs and ingenuity, invented a reaſon for this appearance, which, although it did not ſatisfy himſelf, ſeemed ſo plauſible to them, that it diſpelled their fears [a].

This appearance, ſo alarming to the Spaniards, is that deviation from the meridian which is called the *variation of the needle*, and is different in different parts of the world; being weſt at ſome places, eaſt at others, and in parts where the variation is of the ſame name its quantity is very different. Sebaſtian Cabot is generally allowed to be the firſt, who, about the year 1497, more accurately aſcertained the reality of this variation, and that it was the ſame to all needles in the ſame place. For a long time after, it was thought to be invariably the ſame, at the ſame place, in all ages; but Mr. Gellibrand, about the year 1625, diſcovered that it was different at different times, in the ſame place. From ſubſequent obſervations, it appears, that this deviation was not a conſtant quantity, but that it gradually diminiſhed; and, at laſt, about the year 1660, it was found that the needle pointed due north at London, and has

[a] Robertſon's Hiſtory of America.

ever ſince been increaſing to the weſtward of the north. It appears, therefore, that in any one place, the variations have a kind of libratory motion, traverſing through the north to unknown limits eaſtward and weſtward [a].

To return to the magnet, it has been obſerved, that no ſubſtance interpoſed between it and iron, can prevent the action of its attractive virtue. All metals (iron excepted) wood, glaſs, fire, water, and even men and animals, afford a free paſſage to its influence. It has been obſerved, moreover, that of two magnets, the north pole of the one attracts the ſouth pole of the other, and repels its north pole; while, on the contrary, the north pole of the ſecond was attracted by the ſouth pole of the firſt, which repelled conſtantly the ſouth pole of the ſecond. The attractive tendency in iron and a magnet is alſo reciprocal; and they are often attached to each other with ſuch force, as to require a conſiderable weight to ſeparate them.

Among the various hypotheſes that have been framed to account for the phenomenons of magnetiſm, I ſhall only mention that of Mr. Euler; who ſuppoſes, that the two principal cauſes, which concur in producing the wonderful properties of the magnet, are, firſt, a particular ſtructure of the internal parts of the magnets, and of magnetical bodies; and, ſecondly, an external agent or fluid, which acts upon and paſſes through theſe pores. This fluid, he ſuppoſes, to be the ſolar atmoſphere, or that ſubtile matter called ether, which fills our ſyſtem. But I ſhall not here expatiate upon theories, which, however ingenious, I have already obſerved, are univerſally allowed to be unſatisfactory. We know that gravitation, electricity, and magne-

[a] See Adams on Electricity; and for an ample account of the Theories of the Variation of the Compaſs, ſee the article *Variation* in Chambers' Cyclopædia.

tiſm exiſt; that they have certain properties; and are productive of certain phenomenons: but what their nature is, what their ſecondary cauſes, is ſtill among the myſteries, which will, perhaps, be for ever inexplicable. The Contemplative Philoſopher will acquieſce in his ignorance with the moſt awful and devout ſentiments of admiration! And, in every view of the material creation, as well as of the moral government of the Divine Being, he may exclaim, in the language of holy writ, "O the depth of the riches both of the wiſdom and knowledge of God! how unſearchable are his works, and his ways paſt finding out!—Of him, and through him, and to him, are all things: to whom be glory for ever. Amen".

LIII. ON EARTHQUAKES.

Hæc deorum immortalium vox putenda eſt, cum agri terræ motu quodam contremiſcunt, et inuſiato aliquid ſono incredibilique prædicunt. CICERO.

Towers, temples, palaces,
Flung from their deep foundations, roof on roof
Cruſh'd horrible, and pile on pile o'erturn'd,
Fall total. MALLET.

THE greater and more formidable phenomenons of Nature, whatever modern philoſophers may attribute to ſecond cauſes, were conſidered by the ancients as the immediate voice of the immortal gods, and the forerunners, in courſe, of ſome extraordinary event. And thus the Roman orator expreſſes himſelf above.—But whether we regard the ſentiments

of the ancients as the reſult of rational piety or apprehenſive ſuperſtition; or whether we conſider the moſt tremendous phenomenon as capable of being explained upon philoſophical principles; there is certainly no reaſon to doubt, that the Omnipotent Being, who firſt ſubjected the material world to the influence of certain invariable laws, may ſo direct the concurrent operations of natural cauſes, as to evince, that he has not left his creation to the fortuitous conſequences of Chance, or the irreſiſtible impulſe of Neceſſity; but that even in this ſublunar ſtate, the various revolutions, not of empires only, but in the face of the great globe itſelf, are ſo many indications, that he inceſſantly exerciſes a moral government over his creatures; and that, in the wiſe diſpenſations of his providence, every event will finally appear to have been conducive to his gracious deſigns, which are the good and happineſs of the whole. Earthquakes, therefore, and all other dreadful phenomenons, may be conſidered, in this light, as the immediate operation of the Deity. "He looketh on the earth, and it trembleth: he toucheth the hills, and they ſmoke".

His hand the lightning forms;
He heaves old Ocean, and he wings the ſtorms.

POPE.

Earthquakes, which are unqueſtionably the moſt dreadful phenomenon of Nature, have not been confined to ſuch countries, as, from the influence of climate, their vicinity to volcanic mountains, or any other cauſe, have been conſidered as more particularly ſubject to them; but their effects, although not in any degree ſo extenſive and calamitous, have been often felt in this iſland. I purpoſe to inquire, in this paper, into the theory and cauſes of thoſe phenomenons, of which the hiſtory of all ages and countries has afforded ſuch terrible examples; exam-

ples, ſo numberleſs, indeed, as to juſtify the emphatical ſaying of an ancient writer, that "we walk upon the carcaſſes of cities, and inhabit only the ruins of our globe".

The globe around earth's hollow ſurface ſhakes,
And is the ceiling of her ſleeping ſons.
O'er devaſtation we blind revels keep;
Whoſe buried towns ſupport the dancer's heel.

YOUNG.

Poetry does not confine its deſcriptions to the beautiful and pleaſing: it ſelects ſome of its richeſt ſubjects from the grand and majeſtic, and even from the tremendous and terrific. Dr. Grainger, in his beautiful poem, the Sugar Cane, gives a dreadful pictureſque deſcription of an earthquake in the Weſt Indies, where that phenomenon is very frequent:

Earthquakes, Nature's agonizing pangs,
Oft ſhake th' aſtonied iſles; the ſolfaterre
Or ſends forth thick, blue, ſuffocating ſteams;
Or ſhoots to temporary flame. A din,
Wild, thro' the mountain's quivering rocky caves,
Like the dread craſh of tumbling planets, roars.
When tremble thus the pillars of the globe,
Like the tall coco by the fierce North blown,
Can the poor, brittle tenements of man
Withſtand the dread convulſion? Their dear homes
(Which ſhaking, tottering, craſhing, burſting, fall)
The boldeſt fly; and, on the open plain
Appall'd, in agony, the moment wait,
When, with diſrupture vaſt, the waving earth
Shall whelm them in her ſea-diſgorging womb.
Nor leſs affrighted are the beſtial kind.
The bold ſteed quivers in each panting vein,
And ſtaggers, bath'd in deluges of ſweat:
The lowing herds forſake their graſſy food,
And ſend forth frighted, woful, hollow ſounds:
The dog, thy truſty centinel of night,
Deſerts his poſt aſſign'd, and, piteous howls.

Wide ocean feels——
The mountain waves, paſſing their cuſtom'd bounds,
Make direful, loud incurſions on the land,
All-overwhelming: ſudden they retreat,
With their whole troubled waters; but, anon,
Sudden return, with louder, mightier force;
(The black rocks whiten, the vext ſhores reſound;)
And yet, more rapid, diſtant they retire.
Vaſt corruſcations lighten all the ſky,
With volum'd flames; while Thunder's awful voice,
From forth his ſhrine, by night and horror girt,
Aſtounds the guilty, and appals the good.

And Mr. Mallet, in his fine poem, the Excurſion, has taken a view of that midland part of Europe, which has been ſo repeatedly the ſcene of the moſt dreadful devaſtations: I mean Italy and the neighbouring iſland of Sicily. He introduces a deſcription, replete with dreadful imagery, of a city on the point of being ſwallowed up by an earthquake; and he expatiates at length upon the ſigns that precede it, as well as upon its cauſes and effects. But as the limits of my paper will not permit me to inſert this deſcription, I ſhall proceed immediately to the different ideas which the moſt ſagacious philoſophers and naturaliſts have entertained with reſpect to this intereſting ſubject.

Earthquakes have been aſcribed by ſome naturaliſts to water, by others to fire, and by others to air; each of theſe powerful agents being ſuppoſed to operate in the bowels of the earth; which, it is aſſerted, every where abounds with huge ſubterraneous caverns, veins, and canals; ſome full of water, others of exhalations, and others replete with ſuch ſubſtances as nitre, ſulphur, bitumen, and vitriol. Hence it is ſuppoſed, that the earth itſelf may be the cauſe of its own ſhaking, when the baſis of ſome large maſs being worn away by a fluid underneath, it ſinks into the ſame, and produces by its weight the phenomenons

obſervable in earthquakes: or they may be occaſioned by ſubterranean water overflowing and cutting out new courſes; or, the water being heated by the ſubterraneous fires, may emit ſuch vapours, blaſts, &c. as may occaſion great concuſſions: or, if the air, which is a collection of vapours raiſed from the earth and water, be pent up in the too narrow bowels of the earth, the ſubterraneous, or its own native heat, rarefying and expanding it, the force with which it endeavours to eſcape may ſhake the earth: and, laſtly, fire may be a principal cauſe of earthquakes, both as it produces the aforeſaid ſubterraneous vapour, and as this vapour (from the different compoſition of which ariſe ſulphur, bitumen, and other inflammable matters) is kindled either by meeting with ſome other fire, or from its colliſion againſt hard bodies, or intermixture with other fluids; by which means, burſting out into a greater compaſs, the place becomes too narrow for it; ſo that preſſing againſt it on all ſides, the adjoining parts are ſhaken; till, having forced itſelf a paſſage, it is at length diſcharged by a volcano.

For each of theſe opinions much may be ſaid; and their reſpective advocates have written copiouſly upon the ſubject.—Dr. Liſter is of opinion, that the cauſe of thunder, lightning, and earthquakes, is the inflammable breath of the pyrites, which is a ſubſtantial ſulphur, that will take fire of itſelf; in a word, as Pliny had obſerved before, that an earthquake is no more than ſubterranean thunder [a].—Dr. Woodward thinks, that the ſubterranean fire (which is continually elevating the water out of the abyſs, or great body of water in the centre of the earth, to furniſh dew, rain, ſprings, and rivers) being diverted from its ordinary courſe by ſome accidental obſtruction in the pores through which it uſed to

[a] Philoſophical Tranſactions, No. 157.

aſcend to the ſurface, becomes by ſuch means, preternaturally aſſembled, in a greater quantity than uſual into one place, and thus cauſes a rarefaction and intumeſcence of the water of the abyſs, putting it into great commotions, and at the ſame time making the like effort on the earth; which, being expanded upon the face of the abyſs, occaſions an earthquake [a].—M. Amontons endeavours to prove, that on the foundation of the new experiments of the weight and ſpring of the air, a moderate degree of heat may bring the air into a condition capable of cauſing earthquakes [b].—Mr. Michell ſuppoſes that they are occaſioned by ſubterraneous fires; which, if a large quantity of water ſhould be let out upon them ſuddenly, may produce a vapour, whoſe quantity and elaſtic force may be fully ſufficient for this purpoſe [c].

But the theory of earthquakes has received conſiderable alterations and improvements from modern electrical diſcoveries. Dr. Stukely urges a variety of objections againſt the common hypotheſis that aſcribes earthquakes to ſubterranean winds, fires, or vapours. He thinks there is no evidence of the cavernous ſtructure of the earth, which this hypotheſis requires. Subterranean vapours he judges altogether inadequate to the effects produced by earthquakes; eſpecially in caſes where the ſhock is of conſiderable extent: for a ſubterraneous power, capable of moving a ſurface of earth only thirty miles in diameter, muſt be lodged at leaſt fifteen or twenty miles below the ſurface, and move an inverted cone of ſolid earth, whoſe baſis is thirty miles in diameter, and axis fifteen or twenty miles, which he thinks abſolutely impoſſible. How much more inconceivable, then, that any ſuch power could produce the earth-

[a] Woodward's Natural Hiſtory of the Earth.
[b] Memoires de l' Acadamie des Sciences, 1703.
[c] Philoſophical Tranſactions, vol. li.

quake of 1755, which was felt in various parts of Europe and Africa, and the Atlantic ocean: or that in Aſia Minor, in the year 17, by which thirteen great cities were deſtroyed in one night, and which ſhook a maſs of earth three hundred miles in diameter; in order to effect which, the moving power, if it had been internal fire or vapour, muſt have been lodged two hundred miles below the ſurface! Moreover, in earthquakes the effect is inſtantaneous, whereas the operation of elaſtic vapour, and the diſcharge of it, muſt be gradual, and require a long ſpace of time; and if they be owing to exploſions, they muſt alter the ſurface of the country where they happened, deſtroy the fountains and ſprings, and change the courſe of its rivers, which, he obſerves, is contradicted by hiſtory and obſervation. To all this he adds, that the ſtrokes which ſhips receive during an earthquake, muſt be occaſioned by ſomething that could communicate motion with much greater velocity than any heaving of the earth under the ſea by the elaſticity of generated vapours, which would only produce a gradual ſwell, and not an impulſe of the water, reſembling a thump againſt the bottom of a ſhip, or ſtriking againſt a rock. Dr. Stukeley, from theſe and other conſiderations, deeming the common hypotheſis inſufficient, urges a variety of reaſons to ſhow that earthquakes were properly electrical ſhocks. Among other phenomenons, either preceding or attending earthquakes, and which confirmed this opinion, he obſerved that the weather was uſually dry and warm for ſome time before an earthquake happened, and that the ſurface of the ground is thus previouſly diſpoſed for that kind of electrical vibration in which it conſiſts; while at the ſame time, in ſome places where earthquakes have happened, the internal parts, at a ſmall depth below the ſurface, are moiſt and boggy; and thence he inſerts that they reach very little below

the ſurface. He adds, that the ſouthern regions are more ſubject to earthquakes than the northern, on account of the greater warmth and dryneſs of the earth and air, which are qualities ſo neceſſary to electricity. It was alſo obſerved, that before the earthquakes at London in 1749, all vegetation was remarkably forward, and electricity is well known to quicken vegetation. They are likewiſe preceded by frequent and ſingular appearances of the *aurora borealis* and *auſtralis*; and by a variety of meteors, which indicate an electrical ſtate of the atmoſphere. And he apprehends, that, in this ſtate of the earth and air, nothing more is neceſſary to produce an earthquake, than the approach of a non electric cloud to any part of the earth, when in a highly electrified ſtate, and the diſcharge of its contents upon it; and that as the diſcharge from an excited tube occaſions a commotion in the human body, ſo the ſhock produced by the diſcharge between the cloud and many miles in compaſs of ſolid earth, muſt be an earthquake, and the ſnap from the contact the noiſe attending it [a].

M. de St. Lazare not only conſiders earthquakes as electrical phenomenons, but has endeavoured to prove the practicability of forming a *counter-earthquake* and *counter-volcano*, or a method of preventing thoſe convulſions in the bowels of the earth, by means of certain electrical conductors which he deſcribes. But, with reſpect to this electrical cauſe, his theory is different from that of Dr. Stukeley. He is of opinion that it is the interruption of the equilibrium between the electrical matter which is diffuſed in the atmoſphere, and that which belongs to the maſs of our globe, and pervades its bowels, which produces earthquakes. If the electrical fluid ſhould be ſuperabundant, as may happen from a va-

[a] Prieſtley's Hiſtory of Electricity, period x, ſect 12.

riety of causes, its current, by the laws of motion peculiar to fluids, is carried toward those places where it is in a similar quantity; and thus it will sometimes pass from the internal parts of the globe into the atmosphere. In such a case, if the equilibrium be reestablished with facility, the current produces no other effect than what he calls *ascending thunder*; but if considerable and multiplied obstacles oppose this reestablishment, the consequence is then an earthquake, the violence and extent of which are in exact proportion to the degree of the interruption of the equilibrium, the depth of the electrical matter, and the obstacles that are to be surmounted. If the electrical furnace be large and deep enough, so as to give rise to the formation of a conduit or issue, a volcano will be produced, the successive eruptions of which, he thinks, are no more in reality than electrical repulsions of the matters contained in the bowels of the earth [a].

Signior Beccaria, likewise, has nearly the same ideas with M. de St. Lazare, that the electric matter which occasions earthquakes, is lodged deep in the bowels of the earth [b]. Dr. Priestley, after having recited the opinions of Stukeley and Beccaria on this head, does not absolutely decide which of these two philosophers has advanced the more probable opinion; but he thinks a more probable general hypothesis than either of them may be formed out of both. Suppose, says he, the electric matter to be some way or other accumulated on one part of the surface of the earth, and, on account of the dryness of the season, not easily to diffuse itself; it may, as Beccaria supposes, force itself a way into the higher regions of the air, forming clouds in its passage out of the vapours which float in the atmosphere, and occasion a sudden shower, which may

[a] Memoire sur un Para-Tremblement de Terre et un Para-Volcan.
[b] Beccaria Lettere dell' Electrismo.

further promote the paſſage of the fluid. The whole ſurface thus unloaded, will receive a concuſſion, like any other conducting ſubſtance, on parting with, or receiving any quantity of the electric fluid. The ruſhing noiſe will likewiſe ſweep over the whole extent of the country. And, upon this ſuppoſition alſo, the fluid, in its diſcharge from the country, will naturally follow the courſe of the rivers, and take the advance of any eminencies, to facilitate its aſcent into the higher regions of the air.

Whether theſe arguments in favour of the electrical hypotheſis be abſolutely concluſive, it is not my intention to inquire. But ſince the above eminent writers have delivered their reſpective opinions on the ſubject, a very ingenious naturaliſt, whoſe cloſe attention to ſubterraneous geography, and the variety of new obſervations and intereſting facts he has adduced, render his opinions highly deſerving of notice, perſiſts in the idea, that ſubterranean fire, and ſteam generated from it, are the true and real cauſes of earthquakes. And he thinks the elaſticity of ſteam, and its expanſive force, are every way capable of producing the ſtupendous effects attributed to earthquakes, when it is conſidered that this expanſive force of ſteam is to that of gunpowder as 140 to 5 [a].

Such are the reſpective hypotheſis concerning earthquakes. I leave my readers to form their own opinions of the probability of each, and ſhall conclude this paper with the following excellent moral lines:

How greatly terrible, how dark and deep
The purpoſes of Heaven! At once o'erthrown,
White age and youth, the guilty and the juſt,

[a] Whitehurſt's Inquiry into the Original State and Formation of the Earth.

(Oh, ſeemingly ſevere !) promiſcuous fall.
Reaſon, whoſe daring eye in vain explores
The fearful providence, confuſed, ſubdued
To ſilence and amazement, with due praiſe
Acknowledges th'Almighty, and adores
His will unerring, wiſeſt, juſteſt, beſt ! MALLET.

LIV. ON VOLCANOS AND SUBTERRANEOUS FIRES.

Horrificis juxta tonat Ætna ruinis,
Interdumque atram prorumpit ad æthera nubem,
Turbine fumantem piceo et candente favilla,
Attollitque globos flammarum, et ſidera lambit :
Interdum ſcopulos avulſaque viſcera montis
Erigit eructans, liquefactaque ſaxa ſub auras
Cum gemitu glomerat, fundoque exæſtuat imo.

VIRGIL.

Etna roars with dreadful ruins nigh,
Now hurls a burſting cloud of cinders high,
Involv'd in ſmoky whirlwinds to the ſky ;
With loud diſploſion, to the ſtarry frame,
Shoots fiery globes, and furious floods of flame :
Now from her bellowing caverns burſt away
Vaſt piles of melted rocks in open day.
Her ſhatter'd entrails wide the mountain throws,
And deep as hell her flaming centre glows.

J. WARTON.

OF all the volcanos, or ignivomous mountains, with which ſo many parts of the earth abound, Mount Etna, or Gibel, in the iſland of Sicily, is unqueſtionably the moſt ancient on record. As Homer, however, who flouriſhed about 980 years before Chriſt, makes no mention of a phenomenon at once ſo tremendous and extraordinary, this mountain is ſuppoſed not to have burned before his time.

Pindar, who lived 480 years after Homer, is the firſt poet who has given us a deſcription of its fiery eruptions. He has feigned the giant Typhœus to be overthrown by Jupiter, and overwhelmed by Etna, whoſe agitations and eruptions were cauſed by his vain attempts to releaſe himſelf from its incumbent preſſure. Of this fiction, Mr. Weſt has given the following tranſlation:

Now under ſulphurous Cuma's ſea-bound coaſt,
  And vaſt Sicilia, lies his ſhaggy breaſt;
By ſnowy Etna, nurſe of endleſs froſt,
  The pillar'd prop of heav'n, for ever preſs'd:
Forth from whoſe nitrous caverns iſſuing riſe
  Pure liquid fountains of tempeſtuous fire,
And veil in ruddy miſts the noonday ſkies,
  While wrapt in ſmoke the eddying flames aſpire,
Or gleaming thro' the night with hideous roar,
Far o'er the redd'ning main huge rocky fragments pour.

But he, Vulcanian monſter, to the clouds
  The fierceſt, hotteſt inundations throws,
While, with the burden of incumbent woods
  And Etna's gloomy cliffs o'erwhelm'd, he glows.
There on his flinty bed outſtretch'd he lies,
  Whoſe pointed rock his toſſing carcaſe wounds:
There with diſmay he ſtrikes beholding eyes,
  Or frights the diſtant ear with horrid ſounds.

Virgil, who ſeems, in my motto, to have copied this ſublime deſcription, has, in the five lines that follow it, introduced Enceladus in the ſame ſituation as Typhœus.

From the conſideration of Earthquakes, in my laſt paper, it is a natural tranſition to Volcanos, or burning mountains; eſpecially as the hypotheſis, that earthquakes are cauſed by ſubterraneous fires, has ſtill ſo many advocates, and is maintained, in particular, by Mr. Whitehurſt, the laſt ingenious naturaliſt who has written upon this ſubject.—This

philoſopher apprehends, that ſubterraneous fire muſt, at different times, have exiſted univerſally in the bowels of the earth, and that in union with water, or by the expanſive power of ſteam, it has produced the immenſe continents, as well as the mountains of our globe, and alſo the univerſal deluge [a].

Dr. Watſon, biſhop of Landaff, has ſome admirable reflections on this ſubject in his Chymical Eſſays. "The moſt remarkable changes (ſays he) which have taken place in the form and conſtitution of the earth, ſince the deluge, have probably been produced by ſubterraneous fires; for it is to their agency that philoſophers aſcribe volcanos and earthquakes; thoſe tremendous inſtruments of nature, by which ſhe converts plains into mountains, the ocean into iſlands, and dry land into ſtagnant pools.

"Dr. Hooke formerly had maintained, that all land had been raiſed out of the ſea by earthquakes; and modern philoſophers ſeem to admit his hypotheſis, though not, perhaps, in its utmoſt latitude. Thus one of them is of opinion, that Iceland, which is bigger than Ireland, has been produced by volcanos in the courſe of ſeveral centuries [b]. Another, after giving an ingenious conjecture concerning the origin of all the tropical low iſles in the South Sea, aſſures us, that of the higher iſles there is hardly one of them which has not ſtrong veſtiges of its having undergone ſome violent alteration by a volcano. Some of them have volcanos ſtill ſubſiſting; others, among which are Otaheite and Huaheine, ſeem to have been elevated, in remote ages, from the bottom of the ſea by ſubterraneous fires [c].

"When theſe fires were firſt kindled; by what ſort of fuel they are ſtill maintained; at what depths

[a] Inquiry into the Original State and Formation of the Earth.

[b] Letters on Iceland by Dr. Uno Von Troil, p. 222.

[c] Obſervations made during a Voyage round the World by Dr. Forſter, p. 151.

below the ſurface of the earth they are placed; whether they have a mutual communication; of what dimenſions they conſiſt; and how long they may continue, are queſtions which do not admit an eaſy deciſion. The ſurface of the earth is admirably fitted for the ſupport of the exiſtence and wellbeing of all the animals which inhabit it. God has given us the ability alſo to penetrate a very little below this ſurface; and as the reward of our induſtry, he has placed within our reach a great variety of uſeful minerals; but as to the central receſſes of the globe, we can never penetrate into them. A gnat eſſaying the feeble efforts of its ſlender proboſcis againſt the hide of an elephant, and attempting thereby to inveſtigate the internal formation of the body of that huge animal, is no unapt repreſentation of man attempting to explore the internal ſtructure of the earth by digging little holes upon its ſurface.

" But though it will ever be impoſſible for us to ſearch far into the bowels of the earth, or to imitate in an extenſive degree, the great operations which are conſtantly carrying on beneath its ſurface, yet it affords a curious mind no mean degree of ſatisfaction to be able, by obvious experiments to form ſome reaſonable conjectures concerning them.

" Mr. Lemery[a], as far as I have been able to learn, was the firſt perſon who illuſtrated, by actual experiment, the origin of ſubterraneous fires. He mixed twenty-five pounds of powdered ſulphur with an equal weight of iron filings; and having kneaded the mixture together, by means of a little water, into the conſiſtence of a paſte, he put it into an iron pot, covered it with a cloth, and buried the whole a foot under ground. In about eight or nine hours time the earth ſwelled, grew warm, and cracked; hot ſulphureous vapours were perceived;

[a] Cours de Chemie, p. 176.

a flame which dilated the cracks was obſerved; the ſuperincumbent earth was covered with a yellow and black powder: in ſhort, a ſubterraneous fire, producing a volcano in miniature, was ſpontaneouſly lighted up from the reciprocal actions of ſulphur, iron, and water.

"That part of this experiment which relates to the production of fire, by the fermentation of iron filings and ſulphur when made into a paſte, has been frequently repeated ſince the time of Mr. Lemery. I myſelf have made it more than once, but I have nothing material to add to his account, except that the flame, when the experiment is made in the open air, is of very ſhort duration; and the whole maſs, after the extinction of the flame, continues at intervals, for a longer or ſhorter time, according to its quantity, to throw out ſparks; and that a ladle full of the ignited maſs, being dropped drown from a conſiderable height, deſcends like a ſhower of red-hot aſhes, much reſembling the paintings of the eruptions of Mount Veſuvius, which may be ſeen at the Britiſh Muſeum. It has been obſerved, that large quantities of the materials are not requiſite to make the experiment ſucceed, provided there be a due proportion of water: half a pound of ſteel filings, half a pound of flower of brimſtone, and fourteen ounces of water will, when well mixed, acquire heat enough to make the maſs take fire.

"That heat and fire ſhould be generated from the ſpontaneous actions of minerals upon each other, is a phenomenon by no means ſingular in nature, how difficult ſoever it may be to account for it. The heat of putreſcent dunghils, of the fermenting juices of vegetables, and, above all, the ſpontaneous firing of hay not properly dried, are obvious proofs that vegetables poſſeſs this property as well as minerals. In both vegetables and minerals, a definite quantity of moiſture is requiſite to enable them to commence

that inteſtine motion of their parts, which is neceſſary for the production of fire. Iron and ſulphur would remain mixed together for ages without taking fire, if they were either kept perfectly free from moiſture, or drenched with too much water; and vegetables in like manner, which are quite dry, or exceeding wet, are incapable of taking fire while they continue in that ſtate [a].

"But though it is certain from the experiment, that mixtures of iron and ſulphur, when moiſtened with a proper quantity of water, will ſpontaneouſly take fire; yet the origin of ſubterraneous fires cannot, with any degree of probability, be referred to the ſame principle, unleſs it can be ſhown that nature has combined together in large quantities iron and ſulphur, and diſtributed the compoſition through various internal parts of the earth.

"Now that this is really the caſe we can have no doubt. There is, perhaps, no mineral more commonly met with than that which is compoſed of iron and ſulphur. It is found not only upon the face of the earth, but at the greateſt depths below it, to which mines have been hitherto driven; not only in England or Italy, Europe or Aſia, but in all parts of the world. This mineral is called in ſome parts of England, copperas-ſtone; in others, brazil; in others, braſs-lumps; in others, ruſt-balls; in others, horſe-gold; in others, marcaſite; though naturaliſts are now, I think, agreed to give that name to ſuch mineral bodies as are angular and cryſtallized, eſpecially into a cubical form. The ſcientific name is *pyrites*,—fiery: a denomination expreſſive enough of the property which this mineral has of ſtriking fire with ſteel, and of ſpontaneouſly taking fire, when laid in heaps, and moiſtened with water.

"Sulphur and iron are the chief conſtituent parts

[a] Animal ſubſtances, when laid on heaps, have been obſerved to take fire.

of the pyrites; arsenic, however, is sometimes united with the iron instead of sulphur, and sometimes sulphur and arsenic are both of them combined with iron. The pyrites also, accidentally, contains copper, silver, and perhaps, gold: hence the pyrites has been distinguished by mineralogists into various sorts, by attending, either to its internal constitution, as the iron, the copper, the sulphureous, the arsenical pyrites; or to its external figure, as the pyramidal, the cubical, the spherical, the prismatic pyrites; or to its colour, as the gray, white, yellowish, yellow, orange pyrites.

"Though the reader may have never contemplated the various species of the pyrites in any cabinet of natural history, or taken notice of such kinds as are commonly to be met with in chalk-pits, in beds of clay, or upon the seashore in many places of England, yet the yellowish matter, often adhering to, or mixed with the substance of pit-coal, cannot, surely, have escaped his observation: that matter consists of sulphur and iron, and is a species of the pyrites. So much of this sort of the pyrites is dug up together with the coal, at Whitehaven, Newcastle, and other places, that people are employed to pick it out from among the coal, lest it should vitiate its quality, and render it less saleable. The pieces of the pyrites which are separated from the coal, are not thrown aside as useless, but laid in heaps, for a purpose to be mentioned hereafter; and these heaps, not many years since, took fire both at Whitehaven and in the neighbourhood of Halifax. The same accident was observed above a hundred years ago at Puddle Wharf in London, where heaps of coal which contained much of this pyrites took fire[a].

"Though Lemery was the first person who, by artificial mixtures of sulphur and iron, produced

[a] Jorden of Miner. Wat. C. xiv.

ſire, yet that natural mixtures of theſe ſubſtances would ſpontaneouſly take fire, was known before he made his experiment. Thus, to omit what is ſaid by Pliny and the ancients, we are told by good authority, that one Wilſon at Ealand in Yorkſhire, about the year 1664 or before, had piled up in a barn many cart-loads of the pyrites, or braſs-lumps, as they were called by the colliers, for ſome ſecret purpoſes of his own: the roof of the barn happening to be bad, the pyrites were wetted by the rain; in this ſtate they began to ſmoke, and preſently took fire, and burned like redhot coal [a].

"We have an account, in the Philoſophical Tranſactions for 1693, of a covetous maſter of a copperas work at Whiteſtable in Kent, who, in order to break his neighbour's work, had engroſſed all the pyrites or copperas-ſtone in the country: he built a ſhed over two or three hundred tons of theſe ſtones, to keep off the rain. In the ſpace, however, of ſix or ſeven months, the maſs (being probably wetted by the moiſture of the atmoſphere, or by the rain, which, notwithſtanding the ſhed, might have fallen upon it) took fire and burned for a week; it quite deſtroyed his ſhed, and diſappointed all his hopes of profit; for the pyrites was in part converted into a ſubſtance like melted metal, and in part it looked like redhot ſtones: all the ſulphur was conſumed, and the neighbourhood was miſerably afflicted by the noxious exhalation which it ſent forth.

"In the month of Auguſt 1751, the cliffs near Charmouth in Dorſetſhire took fire, in conſequence of a heavy fall of rain after a hot and dry ſeaſon, and they continued at intervals to emit flame for ſeveral years.—Theſe cliffs conſiſt of a dark-coloured bituminous loam, in which are imbedded large quantities of different kinds of the pyrites. The ſame

[a] Power's Microſ. Obſer. p. 62.

kind of flame has been frequently observed in the Cornish mines, and this mineral fire sometimes leads to the discovery of a mine; but wherever it is found to exist, the iron pyrites is generally discovered near it [a].

"There are some sorts of earth from which alum is made, which abound so much with the pyrites, that the proprietors of the works are forced to keep them constantly well watered, in order to prevent their taking fire.—But it would be useless to pursue this subject further; we have adduced proof sufficient, that nature furnishes materials, which, under certain circumstances, may become the occasion of subterraneous fires. The requisite circumstances are a proper quantity of the materials, a proper portion of water to moisten them, and, perhaps, a communication with the air may be necessary. A small quantity of the pyrites is sufficient to kindle a fire; water is almost every where found in such great plenty below the surface of the earth, that it constitutes one of the greatest impediments to our sinking pits to any great depth; and air, if it should be thought absolutely necessary to the spontaneous firing of the pyrites, may be conceived either to accompany the water in its dripping, or to descend into the innermost parts of the earth through the fissures which are found upon its surface. When a subterraneous fire is once kindled, it may be supported for ages by other substances, as well as by those which first gave rise to it: thus, if a quantity of the pyrites should take fire in a stratum of coal, or of shale, or of any other substance strongly impregnated with bitumen, the fire might continue till the stratum was consumed [b].

[a] Philos. Trans. vol. lii. p. 119.

[b] There are some coaleries on fire now in Scotland, which were on fire in the time of Agricola.—Pennant's Tour in Scotland, part ii. p. 201. See an account of the coaleries on fire in Staffordshire, in Dr. Plott's Nat. Hist. of that County; and of the substances sublimed from the burning coalpits at Newcastle, in Philos. Trans. for 1676.

"There are such a great number of volcanos now subsisting in every quarter of the globe, and so many unequivocal vestiges of others, which in length of time have become extinct, that some philosophers think they have reason on their side in supposing, either that the earth, at some considerable distance below its surface, is surrounded with a stratum of ignited matter of a definite thickness; or that the whole central part of it is nothing but a mass of melted minerals, which every where struggling for vent, bursts forth where there is the least resistance, shivering into rude fragments the superincumbent crust of earth, and deluging with mountainous torrents of liquid fire the adjoining countries".

This account of the origin of volcanos and subterraneous fires, as it is thus confirmed both by experiments and facts, will, I have no doubt, be very satisfactory to my readers. In my next paper I shall offer some further observations, which appear to me of no small importance in the discussion of this curious and interesting subject.

LV. FURTHER REFLECTIONS ON VOLCANOS;

WITH A REFUTATION OF SOME OBJECTIONS DEDUCED FROM VOLCANIC PHENOMENONS, AGAINST THE TRUTH OF REVELATION.

> The fluid lake that works below,
> Bitumen, ſulphur, ſalt, and iron ſcum,
> Heaves up its boiling tide. The lab'ring mount
> Is torn with agonizing throes. At once,
> Forth from its ſide diſparted, blazing pours
> A mighty river; burning in prone waves,
> That glimmer thro' the night, to yonder plain.
> Divided there, a hundred torrent ſtreams,
> Each ploughing up its bed, roll dreadful on,
> Reſiſtleſs. Villages, and woods, and rocks,
> Fall flat before their ſweep. The region round,
> Where myrtle walks and groves of golden fruit
> Roſe fair; where harveſt wav'd in all its pride;
> And where the vineyard ſpread its purple ſtore,
> Maturing into nectar; now deſpoil'd
> Of herb, leaf, fruit and flow'r, from end to end
> Lies buried under fire, a glowing ſea! MALLET.

BESIDE the aſtoniſhing exploſion of flames and ſmoke, of cinders and burning rocks, the eruptions of volcanos exhibit a dreadful phenomenon, in prodigious inundations of liquid fire, which bear inevitable deſtruction with them. The Italians give the name of *lava* to theſe fiery ſtreams. This lava conſiſts of a mixture of ſtones, ſand, earth, metallic ſubſtances, ſalt, &c. calcined, rendered fuſible, and vitrified, by the fire of the volcanos; but as the maſs, of which it originally conſiſts, is very heterogeneous, the lava, when cold, appears under various forms and colours. The pureſt ſort is a hard, black, homogeneous compact glaſs. There is another ſpecies which is hard, heavy, and compact, like mar-

ble; ſuſceptible of a very fine poliſh; and converted, at Naples, to a variety of domeſtic uſes. There is another kind, which is a groſſer ſtone, commonly aſh-coloured, and uſed both for building, and for paving the ſtreets. That which is found on the ſurface is ſtill more groſs and ſpongy, reſembling the ſcoriæ, or recrements, of melted metals.

It would carry me too far beyond the limits of this paper, if I were to enter into a hiſtorical account of the eruptions of volcanos. Thoſe of Etna and Veſuvius only would occupy many volumes. The violent eruption of Veſuvius, in 1767, is reckoned the 27th, ſince that which deſtroyed the cities of Herculaneum and Pompeii, in the reign of emperor Titus; and this eruption of 1767, has been ſucceeded by nine others. Of the eruptions of Etna, Mr. Oldenburg has given a hiſtorical account in the Philoſophical Tranſactions, No. xlviii. p. 967. The laſt very great eruption of this mountain was in the year 1669. The progreſs of the lava, or fiery deluge above deſcribed, was at the rate of a furlong a day. It advanced into the ſea 600 yards, and was then a mile in breadth. It had deſtroyed, in forty days, the habitations of 27,000 perſons; and of 20,000 inhabitants of the city of Catanea, only 3000 eſcaped. This inundation of liquid fire, in its progreſs, met with a lake four miles in compaſs, and not only filled it up, although it was four fathoms deep, but raiſed it into a mountain. Borelli, an ingenious Neopolitan, has calculated, that the matter diſcharged at this eruption was ſufficient to fill a ſpace of 93,838,750 cubit paces. The lava which ran from it is fourteen miles in length, and, in many parts, ſix in breadth. There has been no ſuch eruptions ſince, although there have been ſigns of many, more terrible, that preceded it.

A diſcuſſion of all the phenomenons obſervable in volcanos, would be as impracticable, in this paper,

as a historical account of their eruptions. I shall, therefore, confine myself now to such observations, as have not been generally attended to. Among the other appearances of our globe, which have afforded room to minute philosophers, and superficial inquirers, to cavil at the truths of revelation, may be included the phenomenons of volcanos. A very pleasing and popular writer, in particular, in his description of Etna, has insinuated an objection to the Mosaic account of the Creation, by stating in a light somewhat ludicrous, the observations of an ingenious ecclesiastic of Sicily, who was of opinion, that Mount Etna was many thousand years more ancient than Moses had made the earth [a]. The objections of this ecclesiastic, and of the *soi-disant* philosophers who have adopted them, have been fairly stated, and admirably refuted, by a learned prelate, whose writings do equal honour to his age and country [b]. I cannot do better, therefore, than give it in his own words:

"There is an argument by which some philosophers have endeavoured to overturn the whole system of revelation: and it is the more necessary to give an answer to their objection, as it is become a common subject of philosophical conversation, especially among those who have visited the continent. The objection tends to invalidate, as it is supposed, the authority of Moses; by showing, that the earth is much older than it can be proved to be from his account of the creation, and the scripture chronology. We contend that six thousand years have not yet elapsed, since the creation; and these philosophers contend, that they have indubitable proof of the earth being at the least 14,000 years old; and

[a] Brydone's Tour through Sicily and Malta.

[b] An Apology for Christianity, by R. Watson, D. D. now bishop of Landaff.

they complain that Moſes hangs as a dead weight upon them, and blunts all their zeal for inquiry.

"The Canonico Recupero, who, it ſeems, is engaged in writing the hiſtory of Mount Etna, has diſcovered a ſtratum of lava, which flowed from that mountain, according to his opinion, in the time of the ſecond Punic war, or about 2000 years ago; this ſtratum is not yet covered with ſoil ſufficient for the production of either corn or vines; it requires then, ſays the Canon, 2000 years, at leaſt, to convert a ſtratum of lava into a fertile field. In ſinking a pit near Jaci, in the neighbourhood of Etna, they have diſcovered evident marks of ſeven diſtinct lavas, one under the other; the ſurfaces of which are parallel, and moſt of them covered with a thick bed of rich earth: now the eruption, which formed the loweſt of theſe lavas (if we may be allowed to reaſon, ſays the Canon, from analogy) flowed from the mountain at leaſt 14,000 years ago.—It might be briefly anſwered to this objection, by denying that there is any thing in the Moſaic account, repugnant to this opinion concerning the great antiquity of the earth; for though the riſe and progreſs of arts and ſciences, and the ſmall multiplication of the human ſpecies, render it almoſt to a demonſtration probable, that man has not exiſted longer on the ſurface of this earth, than according to the Moſaic account; yet, that the earth itſelf was then created out of nothing, when man was placed upon it, is not, according to the ſentiments of ſome philoſophers, to be proved from the original text of ſacred ſcripture[a]; we might, I ſay, reply, with theſe philoſophers, to this formidable objection of

[a] It is the opinion of ſome philoſophers, that the ſubmarine volcanos exiſted in the chaotic maſs, antecedent to the creation of the world. The inquiſitive reader will find this argument illuſtrated in Kirwan's Elements of Mineralogy, and Whitehurſt's Inquiry into the original State and Formation of the Earth.

the Canon, by granting it in its full extent: we are under no neceſſity, however, of adopting their opinion, in order to ſhow the weakneſs of the Canon's reaſoning. For, in the firſt place, the Canon has not ſatisfactorily eſtabliſhed his main fact, that the lava in queſtion, is the identical lava, which Diodorus Siculus mentions to have flowed from Etna in the ſecond Carthaginian war; and, in the ſecond place, it may be obſerved, that the time neceſſary for converting lava into fertile fields, muſt be very different, according to the different conſiſtencies of the lavas, and their different ſituations, with reſpect to elevation or depreſſion; to their being expoſed to winds, rains, and to other circumſtances; juſt as the time, in which the heaps of iron ſlag (which reſembles lava) are covered with verdure, is different at different furnaces, according to the nature of the ſlag, and ſituation of the furnace; and ſomething of this kind is deducible from the account of the Canon himſelf; ſince the crevices of this famous ſtratum are really full of rich, good ſoil, and have pretty large trees growing in them.

"But if this ſhould be thought not ſufficient to remove the objection, I will produce the Canon an analogy in oppoſition to his analogy, and which is grounded upon more certain facts. Etna and Veſuvius reſemble each other in the cauſes which produce their eruptions, in the nature of their lavas, and in the time neceſſary to mellow them into ſoil fit for vegetation; or, if there be any ſlight difference in this reſpect, it is probably not greater than what ſubſiſts between differnet lavas of the ſame mountain. This being admitted, which no philoſopher will deny, the Canon's analogy will juſt prove nothing at all, if we can produce an inſtance of ſeven different lavas (with interjacent ſtrata of vegetable earth) which have flowed from Mount Veſuvius, not in the ſpace of 14,000, but of ſomewhat leſs

than 1700 years; for then, according to our analogy, a ſtratum of lava may be covered with vegetable ſoil, in about 250 years, inſtead of requiring 2000 for the purpoſe. The eruption of Veſuvius, which deſtroyed Herculaneum and Pompeii, is rendered ſtill more famous by the death of Pliny, recorded by his nephew, in his letter to Tacitus; this event happened in the year 79; it is not yet then quite 1700 years, ſince Herculaneum was ſwallowed up: but we are informed by unqueſtionable authority, that the matter which covers the ancient town of Herculaneum, is not the produce of one eruption only; for there are evident marks that the matter of ſix eruptions has taken its courſe over that which lies immediately above the town, and was the cauſe of its deſtruction. The ſtrata are either of lava or burnt matter, *with veins of good ſoil between them* [b].—I will not add another word upon this ſubject; except that the biſhop of the dioceſe was not much out in his advice to Canonico Recupero—to take care, not to make his mountain older than Moſes; though it would have been full as well to have ſhut his mouth with a reaſon, as to have ſtopped it with the dread of an eccleſiaſtical cenſure."

In this complete refutation of a ſeemingly irreſiſtible argument, the intelligent and candid reader will obſerve, on what weak foundations are urged many other arguments againſt revelation, by the patrons of infidelity. A more extenſive knowledge of the ſubject, in this particular inſtance, would have prevented the haſty petulance and momentary triumph of minds, not ſufficiently informed, and not only previouſly diſpoſed, perhaps, but even anxious and impatient to diſbelieve. In like manner, thoſe who are at all converſant with the deiſtical controverſy, will recollect how many arguments have been ad-

[a] Sir William Hamilton's Remarks on the Soil of Naples, &c. Philoſ. Tranſ. vol. lxi.

vanced against passages in the sacred writings, which a greater degree of critical learning, and a better acquaintance with the manners, customs, and particular circumstances of those times, would have proved to be frivolous and groundless. Yet these objections, although refuted a thousand times to the satisfaction of all competent judges, will still continue to be urged with confidence and exultation, and as eagerly adopted by ignorance, and (by what is perfectly compatible with infidelity) by credulity itself: so very justly, therefore, may the poet's observation be applied to such speculators in philosophy and religion:

"A little learning is a dangerous thing".

Sir William Hamilton, who has resided so many years, in a public character at Naples, and who, with such credit to his country and to himself, has pursued a variety of literary and philosophical researches, has thrown great light on the history of volcanos In the various letters which he has sent to the Royal Society, on this curious and interesting subject, he has demonstrated that these formidable phenomenons fulfil the most beneficial purposes, by serving as spiracles or tunnels to those subterraneous fires, which would otherwise render the dreadful effects of earthquakes more dreadful still [a]. In one letter, moreover, he has mentioned some particulars which afford an excellent lesson to all who are fond of exploring Nature in her wonderful operations; teaching them not to form rash and premature conclusions from appearances only, but to proceed in their researches with patient and steady investigation. He has demonstrated, that many of the revolutions in the face of the globe, have been effected by abso-

[a] The dread volcano ministers to good;
Its smother'd flames might undermine the world:
Loud Etnas fulminate in love to man. YOUNG.

lute chymical proceſſes, carried on by Nature, on a more wonderful and extenſive ſcale, than the puny efforts of human art.

"The gulfs of Gaetta and Terracina (ſays Sir William[a]) may, in the courſe of time, become another Campo Felice: for the rich and fertile plain ſo called, which extends from the bay of Naples to the Appenines, behind Caſerta and Capua, has evidently been entirely formed by a ſucceſſion of ſuch volcanic eruptions. Veſuvius, the Solfaterra, and the high volcanic grounds, on the greater part of which the city of Naples is built, were once probably iſlands; and we may conceive the iſlands of Procita, Iſchia, Ventotiene, Palmarole, Ponza, and Zannone, to be the outline of a new portion of land intended by Nature to be added to the neighbouring continent; and the Lipari iſlands (all of which are volcanic) may be looked upon in the ſame light, with reſpect to a future intended addition to the iſland of Sicily.

"The more opportunities I have of examining this volcanic country, the more I am convinced of the truth of what I have already ventured to advance, which is, that volcanos ſhould be conſidered in a *creative* rather than in a *deſtructive* light. Many new diſcoveries have been made of late years, particularly in the ſouth ſeas, of iſlands which owe their birth to volcanic exploſions; and ſome, indeed, where the volcanic fire ſtill operates. I am inclined to believe, that upon furthur examination, moſt of the elevated iſlands, at a conſiderable diſtance from continents, would be found to have a volcanic origin; as the low and flat iſlands appear in general to have been formed of the ſpoils of ſea productions, ſuch as corals, madrepores, &c.

"Thoſe who have not had an opportunity of ex-

[a] Philoſ. Tranſ. vol. xxxvi. part 2, for 1786.

amining a volcanic country, as I have for more than twenty years, would little ſuſpect, that many curious productions and combinations of lavas and tuffas [a], were of a volcanic origin; eſpecially when they have undergone various chymical operations of Nature, ſome of which have been capable of converting tuffas, lavas, and pumice ſtone into the pureſt clay.

"I have obſerved, that young obſervers in this branch of natural hiſtory, have been too apt to fall into the dangerous error of limiting the order of Nature to their confined ideas: for example, ſhould they ſuſpect a mountain to have been a volcano, they immediately climb to the ſummit to ſeek for the crater; and if they neither find one, nor any ſigns of pumice ſtone, directly conclude ſuch a mountain not to be volcanic: whereas, only ſuppoſe Mount Etna to have ceaſed erupting for many ages, and that half of its conical part ſhould have mouldered away by time (which would naturally be the conſequence) and the harder parts remain in points, forming an immenſe circuit of mountains (Etna extending its baſis more than 150 miles); ſuch an obſerver as I have juſt mentioned would certainly not find a crater on the top of any of theſe mountains; and his ideas would be too limited to conceive, that this whole range of mountains were only part of what once conſtituted a complete cone and crater of a volcano. It cannot be too ſtrongly recommended to obſervers in this, as well as in every other branch of natural hiſtory, not to be over haſty in their deciſions; not to attribute every production they meet with to a ſingle operation of Nature, when perhaps it has undergone various, of which I have given examples in the iſland which is the principal ſubject

[a] The tuffa, or tufa, is a ſtone formed of volcanic aſhes, concreted with various other ſpecies of ſtone, in which argil predominates. It is harder than marble, but ſtill porous and ſpongy.

of this letter[a]. That which was one day in a calcareous ſtate, and formed by an inſect in the ſea, becomes vitrified in another, by the action of the volcanic fire, and the addition of ſome natural ingredients, ſuch as ſea ſalts and weeds, and is again transformed to a pure clay, by another curious proceſs of Nature. The naturaliſt may indeed decide as to the preſent quality of any natural production; but it would be preſumptuous in him to decide as to its former ſtates. As far as I can judge in this curious country, active Nature ſeems to be conſtantly employed in compoſing, decompoſing, and recompoſing; but ſurely for all wiſe and benevolent purpoſes, though on a ſcale, perhaps, too great and extenſive for our limited comprehenſion".

[a] The iſland of Ponza.

LVI. ON THE ART OF NAVIGATION.

Inventâ ſecuit primus qui nave profundum,
Et rudibus remis ſollicitavit aquas;
Tranquillis primus trepidus ſe credidit undis,
Littora ſecuro tramite ſumma legens:
Mox longos tentare ſinus, et linquere terras,
Et leni cœpit pandere vela noto:
Aſt ubi paulatim præceps audacia crevit,
Cordaque languentem dedicere metum;
Jam vagus irrupit pelago, cœlumque ſecutus,
Ægeas hyemes, Ioniaſque domat. CLAUDIAN.

First on the wave the ſavage ſees afloat,
With uncouth oars, his juſt invented boat;
With timid eye the tranquil water views,
And cloſe to ſhore his courſe ſecure purſues:
To catch the ſouthern breeze he next eſſays,
And ſpreads the ſail to croſs the ſpacious bays:
Then, by degrees, forgot dejecting fears,
No more with aſpect dread the ſea appears;
Intrepid grown, he ſtretches to the main,
Nor can the ſhores his eager bark detain;
But far away, the heav'ns alone his guide,
He braves th' Egean ſtorms and fierce Ionian tide.
L***.

IT is not an ill-founded preſumption, that all the early migrations of mankind were made by land. The ocean, which every where ſurrounds the habitable earth, as well as the various arms of the ſea, which ſeparate one region from another, though deſtined to facilitate the communication between diſtant countries, ſeem, at firſt, to be formed to check the progreſs of man, and to mark the bounds of that part of the globe to which Nature had confined him. It was long, we may ſuppoſe, before men attempted to paſs this formidable barrier, and became ſo ſkilful and adventurous as to commit themſelves to the

mercy of the winds and waves, or to quit their native ſhore in queſt of remote and unknown regions.

Horace ſeems to have this idea, and to conſider the firſt voyager as poſſeſſed of an intrepidity more than human:

Circa pectus erat, qui fragilem truci
Commiſit pelago ratem
Primus ———
Necquicquam Deus abſcidit
Prudens oceano diſſociabili
Terras, ſi tamen impiæ
Non tangenda rates tranſiliunt vada.

Or oak, or braſs, with triple fold,
Around that daring mortal's boſom roll'd,
Who firſt, to the wild ocean's rage,
Launch'd the frail bark———
Jove has the realms of earth in vain
Divided by the inhabitable main,
If ſhips profane with fearleſs pride,
Bound o'er th' inviolable tide. FRANCIS.

Navigation and ſhip-building are ſuch complicated arts, that they require the ingenuity, as well as experience, of many ſucceſſive ages, to bring them to any degree of perfection. From the raft or canoe, which firſt ſerved to carry a ſavage over the river that obſtructed him in the chaſe, to the conſtruction of a veſſel capable of conveying a numerous crew, with ſafety, to a diſtant coaſt, the progreſs of improvement is immenſe. Many efforts muſt have been made, many experiments tried, and much labour and invention employed, before men could accompliſh this arduous and important undertaking. The rude and imperfect ſtate in which navigation is ſtill found, among all nations that are not conſiderably civilized, correſponds with this account of its progreſs, and demonſtrates that, in early times, the art was not ſo far improved as to enable men to

undertake diſtant voyages, or to attempt remote diſcoveries.

Lucretius enumerating the various arts, that were brought to the perfection they had attained in his time, by the obſervation of ſucceſſive artiſts, improving upon new hints and augmenting experience, begins firſt with this important ſcience:

Navigia, atque agriculturas, mœnia, leges,
Arma, vias, veſtes, et cætera de genere horum,
Præmia, delicias quoque vitæ funditus omneis,
Carmina, picturas, et dædala ſigna polire,
Uſus, et impigræ ſimul experientia mentis
Paulatim docuit pedetentim progredientis.
Sic unum quicquid paulatim protrahit ætas
In medium ratioque in luminis eruit oras.
Namque aliud ex alio clareſcere corde videbant
Artibus, ad ſummum donec venêre cacumen.

Thus ſhips, thus clothes, thus wine, and oil began;
And towns, the comfort and ſupport of man;
But better'd, all to due perfection brought,
By ſearching wits, from long experience taught,
Thus time, and thus ſagacious men produce
A thouſand things or for delight or uſe;
For one thing known does vigorous light impart
For further ſearch, and leads to height of art.

CREECH.

There will ever be ſpeculators, fond to conjecture concerning the origin of things, however remote in time, and enveloped in obſcurity. Various, in courſe, have been the conjectures concerning navigation; conjectures, which however unſatisfactory, are yet ſo far intereſting, as they furniſh ſome pleaſing ſcope for ingenious, as well as fanciful reflections. Among the ancients, the poets refer the invention of the art of navigation to Neptune; others to Bacchus, others to Hercules, others to Jaſon, and others to Janus, who is ſaid to have conſtructed the firſt ſhip. Hiſtorians aſcribe it to

the Egenites, the Phenicians, and the ancient inhabitants of Britain. Some will have it, that the firſt hint was taken from the flight of the kite; others from the motion of fiſhes in general; and others, to that of the nautilus, a curious ſhellfiſh, in particular; while a learned editor of Virgil's Georgics believes, that an alder-tree, grown hollow with age, and falling into the river on which it was planted (for this tree delights in a moiſt ſoil and the banks of rivers) gave the firſt hint toward navigation:

Tunc alnos primum fluvii ſenſêre cavatas:

Then firſt the rivers hallowed alders bore.

And thus Dryden has poetically delivered his ſentiments on the ſubject:

By viewing Nature, Nature's handmaid, Art,
  Makes mighty things from ſmall beginnings grow:
The fiſhes firſt to ſhipping did impart,
  Their tail the rudder, and their head the prow.

Some log perhaps upon the waters ſwam,
  An uſeleſs drift, which rudely cut within,
And hollowed firſt, a floating trough became,
  And croſs ſome rivulet paſſage did begin.

In ſhipping ſuch as this, the Iriſh kern,
  And untaught Indians on the ſtream did glide:
Ere ſharp-keel'd boats to ſtem the flood did learn,
  Or fin-like oars did ſpread from either ſide.

Add but a ſail, and Saturn ſo appear'd,
  When from loſt empire he an exile went,
And with the golden age to Tyber ſteer'd,
  Where coin and commerce firſt he did invent.

Rude as their ſhips was navigation then;
  No uſeful compaſs or meridian known;
Coaſting, they kept the land within their ken,
  And knew the north but when the poleſtar ſhone.

Scripture refers the origin of ſo uſeful an invention to God himſelf, who gave the firſt ſpecimen in the ark built by Noah: for the raillery which that good patriarch underwent on account of his enterpriſe, is a ſufficient demonſtration, that the world was then ignorant of any thing like navigation, and that they even thought it impoſſible.

But whatever be the origin of this art, and whatever nation may claim the honour of inventing it, or of having rendered it ſubſervient to the noble advantages of commerce, it is certain, that, among all the nations of antiquity, the ſtructure of their veſſels was extremely rude, and their method of working them no leſs defective. They were unacquainted with ſome of the great principles and operations of navigation, which are now conſidered as the firſt elements on which that ſcience is founded. Though that property of the magnet, by which it attracts iron, was well known to the ancients, its moſt amazing and important virtue of pointing to the poles had eſcaped their obſervation. Deſtitute of this faithful guide, which now conducts the pilot with ſo much certainty in the unbounded ocean, during the darkneſs of the night, and when the heavens are covered with clouds, the ancients had no other method of regulating their courſe, than by obſerving the ſun and ſtars. Their navigation was, in courſe, uncertain and timid. They durſt ſeldom quit ſight of land, but crept along the coaſt, expoſed to all the dangers, and retarded by all the obſtructions, unavoidable in holding ſuch an awkward courſe. An incredible length of time was requiſite for performing voyages, which are now finiſhed in a ſhort ſpace. Even in the mildeſt climates, and in ſeas the leaſt tempeſtuous, it was only during the ſummer months that the ancients ventured out of their harbour. The remainder of the year was loſt in inactivity. It would have been deemed moſt incon-

ſiderate raſhneſs to brave the fury of the winds and waves during the winter.

Thoſe who have written more diffuſively upon the ſubject, have taken a ſurvey of the progreſs of diſcovery and navigation among the ancients; beginning with the Egyptians, and proceeding ſucceſſively with the Phenicians, Jews, Carthaginians, Greeks, and Romans. From this ſurvey, which may be traced from the earlieſt dawn of hiſtorical knowledge to the full eſtabliſhment of the Roman empire, the progreſs of the ancients ſeems to be wonderfully ſlow. It ſeems neither adequate to what we might have expected from the activity and enterpriſe of the human mind, nor to what might have been performed by the powers of the great empires, that ſucceſſively governed the world. If we reject accounts that are fabulous and obſcure; if we adhere ſteadily to the light and information of authentic hiſtory, without ſubſtituting in its place the conjectures of fancy, or the dreams of etymologiſts, we muſt conclude, that the knowledge which the ancients had acquired of the habitable globe was extremely confined. This would ſufficiently appear from a review of ſuch parts of the world as they had never explored. But there is a yet more deciſive proof of this, in an opinion which univerſally prevailed among them, that the earth was divided into five regions, which they diſtinguiſhed by the name of zones. Two of theſe, the neareſt to the poles, they termed frigid zones; and they believed that the extreme cold which reigned perpetually there, rendered them uninhabitable. Another, ſeated under the line, and extending on either ſide toward the tropics, they called the torrid zone; and they imagined it to be ſo burnt up with unremitting heat, as to be equally deſtitute of inhabitants. On the other two zones, which occupied the remainder of the earth, they beſtowed the appellation of temperate;

and they taught that theſe, being the only regions in which li.e could ſubſiſt, were allotted to man for his habitation. This wild opinion was not a conceit of the uninformed vulgar, or a fanciful fiction of the poets, but a ſyſtem adopted by the moſt enlightened philoſophers, the moſt accurate hiſtorians and geographers, in Greece and Rome. According to this theory, a vaſt portion of the habitable globe was pronounced to be unfit for ſuſtaining the human ſpecies. Thoſe fertile and populous regions within the torrid zone, which are now known not only to yield their own inhabitants the neceſſaries and comforts of life, with moſt luxuriant profuſion, but to communicate their ſuperfluous ſtores to the reſt of the world, were ſuppoſed to be the ſeat of perpetual ſterility and deſolation. As all the parts of the globe which the ancients had diſcovered, lay within the northern temperate zone, their opinion that the other temperate zone was inhabited, was founded not on diſcovery, but on reaſoning and conjecture. They even believed that, by the inſufferable heat of the torrid zone, ſuch an inſuperable barrier was placed between the two temperate zones, as would prevent for ever any intercourſe between them.

Nevertheleſs, the diſcoveries of the Greeks and Romans were ſtill very conſiderable, when compared to thoſe of remoter times; and, in the ſecond century of the chriſtian era, geography, enriched by new obſervations, made a very conſpicuous figure, under the auſpices of Ptolemy the philoſopher. The diſcoveries, ſubſequent to theſe times, would lead me into a field of diſcuſſion too extenſive for this number; which I ſhall conclude, therefore, with ſome very ingenious and intereſting reflections on the preſent wonderful perfection of navigation, from a recent publication [a].

[a] Hiſtory of the Voyages and Diſcoveries made in the North; tranſlated from the German of John Reinhold Foſter, LL.D.

"Of all the arts and professions which have at any time attracted my notice, none has ever appeared to be more astonishing and marvellous than that of navigation, in the state in which it is at present; an art which doubtless affords one of the most certain irrefragable proofs of the amazing powers of the human understanding. This cannot be made more evident, than when, taking a retrospective view of the tottering, inartificial craft to which navigation owes its origin, we compare it to a noble and majestic edifice, containing 1000 men, together with their provisions, drink, furniture, wearing-apparel, and other necessaries for many months, beside 100 pieces of heavy ordnance; and bearing all this vast apparatus safely, and as it were on the wings of the wind, across immense seas to the most distant shores. The following example may serve for the present to delineate at full length, as it were, the idea above alluded to. But first I must premise, that a huge, unweildy log of wood, with the greatest difficulty, and in the most uncouth manner, hollowed out in the inside, and somewhat pointed at both ends, and in this guise set on a river for the purpose of transporting two or three persons belonging to one and the same family across a piece of water a few feet deep, by the assistance of a pole pushed against the ground, cannot with any propriety be considered as the image of navigation in its first and earliest stage. For it seems evident to me, that people in the beginning only took three or four trunks of trees, and fastened them together, and then by means of this kind of raft, got across such waters as were too deep for them to ford over, and across which they could not well swim with their children, and various kinds of goods which they might wish to preserve from being wet. The canoe, however, is a specimen of the art in a more advanced state, as this kind of craft is capable of

having direction given to it, and even of so capital an improvement as that of having a sail added to it. For this reason I choose this vehicle for a standard, in preference to a mere raft, to which, imperfect as it is, it is so much superior. Let us, then, compare this with a large majestic floating edifice, the result of the ingenuity and united labour of many hundreds of hands, and composed of a great number of well-proportioned pieces, nicely fastened together by means of iron nails and bolts; and rendered so tight with tow and pitch, that no water can penetrate into it. Now, in order to give motion and direction to this enormous machine, some astonishingly lofty pieces of timber have been fixed upright in it, and so many moveable cross pieces have been added to it, together with such a variety of pieces of strong linen cloth, for the purpose of catching the wind, and of receiving its impulse and propelling power, that the number of them amounts to upward of thirty. For changing the direction of these yards and sails, according to particular circumstances, it has also been requisite to add a vast quantity of cordage and tackling; and, nevertheless, even all this would not be sufficient for the perfect direction and government of the vessel, if there were not fastened to the hinder part of it, by means of hinges and hooks, a moveable piece of wood, very small indeed in proportion to the whole machine, but the least inclination of which to either side is sufficient to give immediately a different direction to this enormous large mass, and that even in a storm, so that two men may direct and govern this swimming island with the same or with greater ease than a single man can do a boat. But if, besides, we consider that, in a vessel like this, not a single piece is put in at random, but that every part of it has its determinate measure and proportion, and is fixed precisely in that place which

is the moſt advantageous for it; that, throughout every part of it, there is diſtributed an aſtoniſhing quantity of blocks, ſtays, and pullies, for the purpoſe of diminiſhing the friction, and of accelerating the motion of theſe parts; that even the bellying and vaulted part of the fabric, together with its ſharp termination underneath, are proportioned according to the niceſt calculations, and the moſt accurately determined rules; that the length and the thickneſs of the maſts, the ſize of the booms and yards, the length, width, and ſtrength of the ſails and tackling, are all in due proportion to one another, according to certain rules founded upon the principles of motion: when we conſider all this, I ſay, our admiration increaſes more and more at this great maſterpiece of human power and underſtanding. Still, however, there are wanting a few traits to complete this deſcription. A man in health conſumes in the ſpace of twenty-four hours, about eight pounds of victuals and drink: conſequently, 800lb. of proviſions are required daily in ſuch a ſhip. Now let us ſuppoſe her to be fitted out for three months only, and we ſhall find that ſhe muſt be laden with 720,000lb. of proviſions. A large forty-two pounder weighs about 6100lb. if made of braſs, and about 5500lb. if of iron; and generally there are twenty-eight or thirty of theſe on board a ſhip of 100 guns, the weight of which, excluſive of that of their carriages, amounts to 183,000lb. On the ſecond deck thirty twenty-four pounders, each of which weighs about 5100lb. and therefore all together, 153,000lb. and the weight of the twenty-ſix or twenty eight twelve pounders on the lower deck amounts to about 75,400lb. that of the fourteen ſix pounders on the upper deck, to about 26,600lb. and beſide that, on the round tops, there are even three pounders and ſwivels. Now, if to this we add, that the complete charge of a forty-two pounder weighs about 64lb.

and that at leaſt upward of 100 charges are required for each gun, we ſhall find this to amount nearly to the ſame weight as the guns themſelves. In addition to this we muſt reflect, that every ſhip muſt have, by way of providing againſt exigencies, at leaſt another ſet of ſails, cables, cordage, and tacklings, which altogether amount to a conſiderable weight. The ſtores, likewiſe, conſiſting of planks, pitch, and tow; the cheſts belonging to the officers and ſailors; the ſurgeon's ſtores, and various other articles requiſite on a long voyage; as alſo the ſmall arms, bayonets, ſwords, and piſtols, are no inconſiderable load; to which we muſt finally add the weight of the crew, which is not very trifling; ſo that one of theſe large ſhips carries at leaſt 2162 tons burden, or 4,324,000lb. and at the ſame time is ſteered and governed with as much eaſe as the ſmalleſt boat. Now, the conſideration of theſe circumſtances alone, is ſufficient to excite the moſt ſerious reflections in a contemplative mind; and yet, if ſuch a ſhip ſailed along the coaſt only, and never loſt ſight of the ſhore, as the navigators of old uſed to do, we might ſtill be tempted to look upon navigation as an eaſy and trifling buſineſs. But the finding the ſtraighteſt and ſhorteſt way over an ocean of more than 60 or 80 degrees in longitude, and 30 or 40 in latitude; or acroſs a track from 4000 to 6000 miles in extent, by day or by night, in fair weather or in foul, as well when the ſky is overcaſt as when it is clear, and often with no other guide than the compaſs, and the being able to determine the true poſition of the ſhip at ſea by the height of the ſun, though this latter be inveloped in clouds, or to direct its courſe by the moon and ſtars with ſuch exactneſs and preciſion, as not to make a miſtake of the value of half a degree or 30 miles; this at leaſt ſhows the progreſs and great perfection of an art practiſed by a ſet of people, of whoſe underſtand-

ings many conceited and ſupercilious landmen have but a mean opinion, and whoſe plain and ſimple manners they frequently take the liberty of turning into ridicule.

A violent ſtorm of wind will make us tremble with fear, even in a ſtrong well-built houſe, and in the midſt of a populous city; yet we have ſeldom or never either ſeen or experienced the vaſt power of the enraged waves, when beat about by the winds, and daſhed againſt each other till they ſeem transformed into froth and vapour, and the whole ſurface of the ocean preſents to the eye a confuſed ſcene of immenſe watery mountains and bottomleſs precipices; and yet on ſuch a ſea as this the true ſeaman, provided he has but a good ſhip, rides with calm and unſhaken courage, and thinks himſelf as ſafe in the midſt of the ocean as in the beſt fortified caſtle".

LVII. ON THE NATURE OF THE TIDES.

Alternate tides in ſacred order run. BLACKMORE.

The ebbs of tides, and their myſterious flow,
We, as art's elements, ſhall underſtand. DRYDEN.

THE tides of the ſea have ever been conſidered among the moſt wonderful phenomenons in nature. The conjectures of the more ancient philoſophers concerning them were equally various, viſionary, and wild. Some of them conſidered the tides as ebullitions occaſioned by ſubterraneous fires, or as the effects of winds and exhalations, or as the conſequence of a rarefaction produced by the beams of

the moon, or as proceeding from the interruption of the ſeas by the continents. It appears, however, that Pliny, Ptolemy, and Macrobius, were not unacquainted with the influence of the ſun and moon upon the tides; and Pliny ſays expreſsly, that the cauſe of the ebb and flow is in the ſun, which attracts the waters of the ocean; and he adds, that the waters riſe in proportion to the proximity of the moon to the earth.

But the moderns have diſcovered, that all the phenomenons of the tides are to be accounted for, from the principle of gravitation. All that is requiſite to their ſolution is, that the earth and moon, and every particle of them, mutually gravitate toward each other. Indeed, the ſagacious Kepler, long ago, conjectured this to be the cauſe of the tides: "If (ſays he) the earth ceaſed to attract its waters toward itſelf, all the water in the ocean would riſe and flow into the moon: the ſphere of the moon's attraction extends to our earth, and draws up the water". This, at that time, was mere conjecture; for ſir Iſaac Newton was the firſt who clearly pointed out the cauſe of this phenomenon, and demonſtrated its agreement with its effects.

The waters of the ocean are obſerved to flow, for certain hours, from the ſouth toward the north; in which motion or flux, which laſts about ſix hours, the ſea gradually ſwells; ſo that entering the mouths of rivers, it drives back the river waters toward their heads. After a continual flux of ſix hours, the ſea ſeems to reſt for a quarter of an hour: it then begins to ebb or retire back again, from north to ſouth, for ſix hours more; in which time, the waters ſinking, the rivers reſume their natural courſe. After a ſeeming pauſe of a quarter of an hour, the ſea again begins to flow as before; and thus it has alternately riſen and fallen twice a day, ſince the creation.

I have obſerved, that in the time of Pliny, the tides were known to be under the influence of the ſun, in a ſmall degree; but, in a much greater, of the moon. It was found, that there was a flux and reflux of the ſea, in the ſpace of twelve hours and forty-eight minutes, which is exactly the time of a lunar day. It was obſerved, that whenever the moon was in the meridian, or, in other words, as nearly as poſſible over any part of the ſea, that the ſea flowed to that part, and made a tide there. On the contrary it was found, that when the moon left the meridian, the ſea began to flow back to its former ſituation, and there might be ſaid to ebb. Thus far the waters of the ſea ſeemed very regularly to attend the motions of the moon. But it appeared, likewiſe, that when the moon was in the oppoſite meridian, as far off as on the other ſide of the globe, there was a tide on this ſide alſo; ſo that the moon produced two tides, one by her greateſt approach to, and another by her greateſt diſtance from us: in other words, the moon, in once going round the earth, produced two tides always at the ſame time; one on the part of the globe directly under her; and the other on the part of the globe directly oppoſite.

Mankind continued for ſeveral ages content with knowing the general cauſe of theſe wonders, hopeleſs of diſcovering the particular manner of the moon's operation; till, as I before obſerved, Kepler firſt conjectured, and Newton demonſtrated, that attraction was the principal cauſe.

The moon has been found, like all the reſt of the planets, to attract, and be attracted by the earth. This attraction prevails throughout our whole planetary ſyſtem. The more matter there is contained in any body, the more it attracts; and its influence decreaſes in proportion as the diſtance, when ſquared, increaſes. This being premiſed, we muſt inquire what will follow, ſuppoſing the moon in the meri-

dian of any tract of the ſea. The ſurface of the water immediately under the moon, is nearer the moon than any other of the globe is; and, therefore, muſt be more ſubject to its attraction than the waters any where elſe. The waters will, therefore, be attracted by the moon, and riſe in a heap, whoſe eminence will be the higheſt where the attraction is greateſt. In order to form this eminence, it is obvious, that the ſurface, as well as the depths, will be agitated; and that wherever the water runs from one part, ſucceeding waters muſt run to fill up the ſpace it has left. Thus, the waters of the ſea, running from all parts, to attend the motions of the moon, produce the motions of the tide; and it is high tide at that part wherever the moon comes over it, or to its meridian.

But when the moon travels onward, and ceaſes to point over the place where the waters were juſt riſen, the cauſe here of their riſing ceaſing to operate, they will flow back by their natural gravity, into the lower parts from which they had travelled; and this retiring of the waters will form the ebbing of the ſea.

Thus, the firſt part of the demonſtration is obvious; ſince, in general, it requires no great ſagacity to conceive, that the waters neareſt the moon are moſt attracted, or raiſed higheſt by the moon. But the other part of the demonſtration, namely, how there come to be high tides at the ſame time, on the oppoſite ſide of the globe, and where the waters are furtheſt from the moon, is not ſo eaſy to conceive. To comprehend this, it muſt be obſerved, that the part of the earth, and its waters, that are furtheſt from the moon, are the parts of all others that are leaſt attracted by the moon: it muſt alſo be obſerved, that all the waters, when the moon is on the oppoſite ſide of the earth, muſt be attracted by it in the ſame direction that the earth itſelf attracts them,

that is, as it were, quite through the body of the earth, toward the moon itſelf. This, therefore, being conceived, it is plain, that thoſe waters which are furtheſt from the moon, will have leſs weight, or gravity toward the centre, than thoſe of any other part on the ſame ſide of the globe; becauſe the moon's attraction (which conſpires with that of the earth, but which decreaſes in proportion as the ſquares of the diſtances increaſe) is there leaſt. The waters, therefore, that are furtheſt from the moon, having leſs gravity, and being lighteſt, will be preſſed on all ſides by thoſe that, having more of the moon's attraction, are heavier: they will be preſſed, I ſay, on all ſides; and, the heavier waters flowing in, will make them ſwell and riſe in an eminence directly oppoſite to that on the other ſide of the globe, cauſed by the more immediate influence of the moon[a].

In this manner, the moon, in one diurnal revolution, produces two tides; the one raiſed immediately under the ſphere of its influence, and the other directly oppoſite to it. As the moon travels, this vaſt body of waters rears upward, as if to watch its motions; and purſues the ſame conſtant rotation. However, in this great work of raiſing the tides, the ſun has no ſmall ſhare: it produces its own tides, conſtantly every day, juſt as the moon does, but in a much leſs degree, becauſe the ſun is at an immenſely greater diſtance. Thus there are ſolar tides and lunar tides. When the forces of theſe two great luminaries concur, which they always do, when they are in either the ſame, or in oppoſite parts of the heavens, they jointly produce a much greater tide, than when they are ſo ſituate in the heavens, as each to make peculiar tides of their own. To expreſs the very ſame thing technically; in the con-

[a] See this, and what follows, illuſtrated clearly by a reference to a plate in Bonnycaſtle's Aſtronomy.

junctions and oppositions of the sun and moon, the attraction of the sun conspires with the attraction of the moon; by which means the high spring tides are formed. But in the quadratures of the sun and moon, the water raised by the one is depressed by the other; and hence the lower neap tides have their production. In a word, the tides are greatest in the syzigies, and least in the quadratures.

This theory, well understood, and the astronomical terms previously known, it may be readily brought to explain the various appearances of the tides, if the earth were covered with a deep sea, and the waters uninfluenced by shoals, currents, straits, or tempests. But in every part of the sea, near the shores, the geographer must come in to correct the calculations of the astronomer. For, on account of the shallowness of some places, and the narrowness of the straits in others, there arises a great diversity in the effect, not to be accounted for without an exact knowledge of the place. In the great depths of the ocean, for instance, a very slow and imperceptible motion of the whole body of water will suffice to raise its surface several feet high; but, if the same increase of water is to be conveyed through a narrow channel, it must rush through it with the most impetuous rapidity. Thus, in the English channel, and the German ocean, the tide is found to flow strongest in those places that are narrowest; the same quantity of water being, in this case, driven through a smaller passage. It is often seen, therefore, pouring through a strait with great force; and, by its rapidity, considerably raised above that part of the ocean through which it runs.

The shallowness and narrowness of many parts of the sea give rise also to a peculiarity in the tides of some parts of the world: for, in many plaees, in our own seas, in particular, the greatest swell of the tide is not while the moon is in its meridian height, and

directly over the place, but some time after it has declined thence. The sea, in this case, being obstructed, pursues the moon with what dispatch it can, but does not arrive with all its waters, till after the moon has ceased to operate. Lastly, from this shallowness of the sea, and from its being obstructed by shoals and straits, we may account for the Mediterranean, the Baltic, and the Black Sea, having no sensible tides. These, although to us they seem very extensive, are not, however, large enough to be affected by the influence of the moon; and, as to their communication with the ocean, through such narrow inlets, it is impossible, that in a few hours they should receive and return water enough to raise or depress them in any considerable degree.

In general, we may observe, that all tides are much higher, and more considerable in the torrid zone, than in the rest of the ocean; the sea in those parts being generally deeper, and less affected by variable winds, or winding shores. One of the greatest tides we know of is that at the mouth of the river Indus, where the water rises thirty feet in height. How great, therefore, must have been the amazement of Alexander's soldiers at such a strange appearance. They who had been always accustomed before to the scarcely perceptible risings of the Mediterranean, or the minute intumescence of the Black Sea, when made at once spectators of a river rising and falling thirty feet in a few hours, must, no doubt, have felt the most extreme awe, and, as we are told by Quintus Curtius, a mixture of curiosity and apprehension. The tides are also remarkably high on the coasts of Malay, in the straits of Sunda, in the Red Sea, at the mouth of the river St. Lawrence, along the coasts of China and Japan, at Panama, and in the gulf of Bengal. The tides at Batsha in the kingdom of Tonquin, which lies in 20° 50′ north latitude, are, however, the most remarkable in the

world. In this port there is but one tide and one ebb in twenty-four hours; whereas, as before observed, in all other places there are two. Besides, there, twice in each month there is no tide at all, when the moon is near the equinoctial, the water being for some time quite stagnant. These, with some other odd appearances, were considered by many as inscrutable; but sir Isaac Newton, with peculiar sagacity, adjudged them to arise from the concurrence of two tides, one from the South Sea, and the other from the Indian Ocean. Of each of these tides there come successively two every day; two at one time greater, and two at another that are less. The time between the arrival of the two greater is considered by him as high tide; the time between the two less, as ebb. In short, with this alone, that great mathematician solved every appearance, and so established his theory as to silence every opposer.

Such is the nature and such the various phenomenons of the tides; a subject which I cannot conclude, without suggesting how much we are bound to adore the benevolent Creator, not only in the goodness which he manifests in the terraqueous globe, but in his astonishing world of waters. The waters of the sea, it has been observed by philosophers, are kept sweet by their motion, without which they would soon putrefy, and spread universal infection. If we look, therefore, for final causes, a great and obvious one is apparent in the tides. Had the sea been made without motion, and resembling a pool of stagnant water, the nobler races of animated nature should shortly be at an end. Nothing would then be left alive but swarms of ill-formed creatures, with scarce more than vegetable life, and subsisting by putrefaction. Were this extensive bed of waters entirely quiescent, millions of the smaller reptile kinds would there find a proper retreat in which to

breed and multiply. They would find there no agitation, no concuſſion in the parts of the fluid to cruſh their feeble frames, or to force them from the places in which they were bred; there they would multiply in ſecurity and eaſe, enjoy a ſhort life, and putrefying, thus again give life to numberleſs others, as little worthy of exiſtence as themſelves. But the motion of this great element effectually deſtroys the number of theſe viler creatures: its currents and its tides produce continual agitation, the ſhock of which they are not able to endure; the parts of the fluid rub againſt each other, deſtroy all viſcidities; and, if I may ſo expreſs myſelf, the ocean acquires health by exerciſe.

LVIII. ON VARIOUS PHENOMENONS OF THE OCEAN.

With wonder mark the moving wilderneſs of waves,
From pole to pole through boundleſs ſpace diffus'd,
Magnificently dreadful! where, at large,
Leviathan, with each inferior name
Of ſea-born kinds, ten thouſand thouſand tribes,
Finds endleſs range for paſture and for ſport.
——————Adoring own
The Hand Almighty, who its channell'd bed
Immeaſureable ſunk, and pour'd abroad,
Fenc'd with eternal mounds, the fluid ſphere;
With every wind to waft large commerce on,
Join pole to pole, conſociate ſever'd worlds,
And link in bonds of intercourſe and love
Earth's univerſal family. MALLET.

IF we look upon a map of the world, we ſhall find that the ocean occupies a conſiderable greater ſurface of the globe than the land is found to do.

This immenſe body of waters is diffuſed round both the old and new continent to the ſouth, and may ſurround them alſo to the north, for what we know; but the ice in thoſe latter regions has ſtopped our inquiries. Although the ocean, properly ſpeaking, is but one extenſive ſheet of water, continued over every part of the globe, without interruption, and although no part of it is divided from the reſt, yet geographers have diſtinguiſhed it by different names; as the Atlantic or Weſtern Ocean, the Northern, Southern, Pacific, Indian, and German Oceans.

In this vaſt receptacle, almoſt all the rivers of the earth ultimately terminate. And yet theſe vaſt and inexhauſtible ſupplies do not ſeem to increaſe its ſtores; for it is neither apparently ſwelled by their tribute, nor diminiſhed by their failure: it continues conſtantly the ſame. Indeed, the quantity of water of all the rivers and lakes in the world is nothing compared to that contained in this prodigious reſervoir. And ſome natural philoſophers have carried their ideas on this ſubject ſo far, as to aſſert, in conſequence of certain calculations, that, if the bed of the ſea were empty, all the rivers of the world flowing into it with a continuance of their preſent ſtores, would take up at leaſt 800 years to fill it again to its preſent height.

Thus great is the aſſemblage of waters diffuſed round our habitable globe; and yet, immeaſurable as it ſeems, it is rendered ſubſervient principally to the neceſſities and conveniencies of ſo little a being as man. Some have perceived ſo much analogy to man in the formation of the ocean, that they have not heſitated to aſſert it was made for him alone. This has been denied by others; and a variety of arguments have been adduced on both ſides, in which I do not think it neceſſary to enter here: for, of this we are certain, that the great Creator has endowed us with abilities to turn this great extent of

waters to our own advantage. He has made these things, perhaps, for other uses; but he has given us faculties to convert them to our own. This much agitated question, therefore, seems to terminate here: we shall never know whether the things of this world were made for our use; but we very well know that we were made to enjoy them. Let us then boldly affirm, that the earth, and all its wonders are ours; since we are furnished with powers to force them into our service. Man is the lord of the whole sublunary creation; the howling savage, the winding serpent, with all the untameable and rebellious offspring of nature, are destroyed in the contest, or driven at a distance from his habitations. The extensive and tempestuous ocean, instead of dividing or limiting his power, only serves to assist his industry, and enlarge the sphere of his enjoyments. Its billows, and its monsters, instead of presenting a scene of terror, serve only to excite and invigorate the courage of this intrepid little being; and the greatest danger that man now fears from the deep, is from his fellow-creatures. Indeed, if we consider the human race as nature has formed them, very little of the habitable globe seems to be made for them. But when they are considered as accumulating the wisdom of ages, in commanding the earth, there is nothing so great, nor so terrible. What a poor contemptible being is the naked savage, standing on the beach of the ocean, and trembling at its tumults! How incapable is he of converting its terrors into benefits; or of saying, Behold an element made solely for my enjoyment!— He considers it as an angry deity, and pays it the homage of submission. But it is very different when he has exercised his mental powers; when he has learned to find his own superiority, and to make it subservient to his commands. It is then that his dignity begins to appear, and that the True Deity

is adored, for having been mindful of man; for having given him the earth for his habitation, and the sea for his inheritance.

Of the various phenomenons of the sea, one of the most obvious is its saltness. Few questions, concerning the natural history of our globe, have been discussed with more attention, or decided with less satisfaction, than that concerning the primary cause of it, which had perplexed the philosophers before the time of Aristotle, and surpassed even the great genius of that philosopher. Father Kircher, after having consulted three and thirty authors upon the subject, could not help remarking, that the fluctuations of the ocean itself were scarcely more various, than the opinions concerning the origin of its saline impregnation.

The question does not seem capable of admitting an illustration from experiment; at least, no experiments have been hitherto made for that purpose; and, therefore, we may be the less surprised at its remaining, nearly as problematical in the present age, as it has been in any preceding. Had any observations been made, three or four centuries ago, ascertaining the then saltness of the sea, at any particular time and place, we might now, by making similar observations at the same place, in the same season, have been able to know, whether the saltness, at that particular place, was an increasing, or a decreasing, or an invariable quantity. This kind and degree of knowledge would have served as a clue to direct us to a full investigation of this matter in general. But it is to be regretted that, till very lately, no such observations have been made with any degree of precision.

One of the principal opinions on this subject, maintained by modern philosophers, and supported, in particular, by Dr. Halley, is, that since river water, in almost every part of the globe, is impreg-

nated, in a greater or leſs degree, by ſea ſalt, the ſea muſt have gradually acquired its preſent quantity of ſalt from the long continued influx of rivers. The water, which is carried into the ſea by the rivers, is again ſeparated from it by evaporation, and being diſperſed over the atmoſphere by winds, it ſoon deſcends in rain or vapour upon the ſurface of the earth; from which it haſtens to pour into the boſom of the ocean, the freſh tributue of ſalt, which it has collected in its inland progreſs. Thus the ſalt conveyed into the ſea, not being a volatile ſubſtance, nor performing an inceſſant circulation, like the water which carries it thither, muſt be a perpetually increaſing quantity; and time enough, it is contended, has elapſed ſince the creation, for the ſea to acquire from this ſource its preſent quantity of ſalt.

Other philoſophers [a], obſerving that large beds of foſſile ſalt are not unfrequent in any quarter of the globe; and conceiving, with great probability, the bottom of the ſea to be analogous in its formation to the ſurface of the earth; have undertaken to derive its ſaltneſs from the beds of rock ſalt, which they ſuppoſe to be ſituate at its bottom; and they are further of opinion, that without ſuch a permanent ſaline principle, the ſea would long ſince have become inſipid, from the freſh water poured into it from an infinity of rivers.

With reſpect to the firſt of theſe opinions, Dr. Watſon, the preſent biſhop of Llandaff, enters into a very ingenious diſquiſition, to ſhow, that the cauſe aſſigned by it for the ſaltneſs of the ſea, is not adequate to its effect; and, as to the ſecond opinion, he obſerves, how ſtrange it is, that what, according to the firſt hypotheſis, is thought ſufficient to account for the ſaltneſs of the ſea, ſhould, in this, be eſteemed inſtrumental in annihilating the ſaltneſs already

[a] Mem. de l'Acad. des Sciences de Berlin, Ann. 1760.

ſuppoſed to exiſt. Againſt this laſt opinion, moreover, he urges an objection of ſome weight; namely, why the waters of the ocean are not perfectly ſaturated with ſalt, if, ever ſince the creation, they have been exerting their powers upon ſuch permanent maſſes of rock ſalt as are thought to be ſituate at its bottom?

Boyle unites, as it were, the two preceding hypotheſes, and takes the ſaltneſs of the ſea to be ſupplied, not only from rocks and other maſſes of ſalt, which at the beginning were, or in ſome countries may yet be found, either at the bottom of the ſea, or at the ſides, where the water can reach them; but alſo from the ſalt which the rivers, rains, and other waters diſſolve, in their paſſage through divers parts of the earth, and at length carry with them into the ſea.

This opinion, biſhop Watſon neither condemns nor adopts; but he obſerves, that Buffon, and the generality of philoſophers, acquieſce in it. He adds, that we are inquiring into the cauſe of a phenomenon, which, it may be ſaid, had no ſecondary cauſe at all. "For it is taken for granted (he continues) in this diſquiſition, that the water which covered the globe in its chaotic ſtate, was not impregnated with ſalt as at preſent, but quite freſh: now this is an opinion concerning a matter of fact, which can never be proved either way; and ſurely we extend our ſpeculations very far, when we attempt to explain a phenomenon, primeval to, or coeval with, the formation of the earth.

"Bernardine Gomeſins, about 200 years ago, publiſhed an ingenious treatiſe upon ſalt: in this treatiſe, after reciting and refuting the opinions of Empedocles, Anaxagoras, and Ariſtotle, upon the ſubject in queſtion, he propoſes his own; wherein he maintains, that the ſea was originally created in the ſame ſtate in which we at preſent find it, and

impregnated, from the very firſt, with the ſalt which it contains. Though this hypotheſis may be conſidered by ſome, rather as a cutting than an untying of the knot, yet it has been embraced by philoſophers of great eminence; and it muſt be owned, that it may be applied to the ſolution of ſome phenomenons with peculiar propriety. Naturaliſts aſſure us, that, though ſome few ſpecies of fiſhes thrive in freſh water, and ſome others live alternately in freſh water and ſalt, yet by far the greateſt number cannot exiſt out of the ſea: now, whether we ſuppoſe the ſea to have become ſalt from the influx of rivers, or from the gradual ſolution of beds of rock ſalt, or from the combined influence of both theſe cauſes, it muſt for ſome years have remained ſo exceedingly freſh, that it will not be an eaſy matter to account for the continuation of the exiſtence of the numberleſs ſpecies of fiſhes, which cannot live in freſh water. This difficulty is not removed by ſuppoſing that fiſhes do not imbibe any part of the ſea's ſaltneſs with their food, and attributing the efficacy of ſea water in preſerving life, to the ſuperior weight with which it compreſſes the organs of reſpiration; for this ſuperior weight is as much an effect of the ſalt diſſolved in it, as the ſaline taſte itſelf. The ſaltneſs of the Caſpian Sea, of the lakes of Mexico and Titicaca, and of other large collections of waters, which have no effluent rivers, nor viſible communication with the ſea, may be as ſucceſsfully explained upon this hypotheſis, *that the ſea was at the creation impregnated with ſalt*, as upon either of the preceding.

"Beſide the opinions of the cauſes of the ſaline impregnation of the ſea, which have been mentioned, there is another, which future ages will, probably, ſee leſs queſtionable to adopt than we do: I mean that which maintains, that ſea-ſalt is conſtantly and

abundantly generated, both on the surface of the earth, and in the bosom of the ocean.

"But how ineffectual soever our attempts may be to explain the cause of the saltness of the sea; yet one might have hoped, that in this age of philosophy and curious navigation, the degree of its saltness in every latitude, and every season of the year, would have been ascertained by accurate experiments. The acquiring knowledge by experiments is a slow and laborious method; but it is, at the same time, a method within our reach: while the theoretical investigation of the proximate cause of any natural phenomenon often surpasses, and that of its ultimate cause always surpasses the apprehension of the human intellect".

The saltness of those great collections of waters, that have no effluent rivers, nor visible communication with the sea, has been mentioned in the preceding quotation. But there are other lakes, through which rivers run into the sea; and these, how extensive soever, are, notwithstanding, very fresh: for admitting the first opinion, concerning the influx of rivers into the sea, and consequently of their salts; yet these rivers do not deposit their salts in the bed of the lake, but carry them, with the currents, into the ocean. Thus the lakes Ontario and Erie, in North America, although for magnitude they may be considered as inland seas, are, nevertheless, fresh water lakes, and kept so by the river St. Lawrence, which passes through them.—I shall only mention further, on this head, the opinions of Bernier and Marsigli: the former ascribes the saltness of the ocean to the fossile or mineral salts, brought into it by subterraneous currents, and dissolved in the water: the latter observes, that, in Provence, the bottom of the sea is wholly stony, and is nothing but a continuation of the mountains of the Cevennes; being even found to consist of several strata, among

which are ſalt and pit-coal; and hence he derives the ſalt and bitterneſs of the ſea-water.

The ſaltneſs of the ſea has been conſidered by ſome as a peculiar bleſſing from Providence, in order to keep ſo great an element pure and wholeſome. This appears to be the ſentiment of ſir Richard Blackmore, in the beautiful lines with which I ſhall conclude this paper; obſerving, however, that the ſaltneſs of the ſea can by no means be conſidered as a principal cauſe in preſerving its waters from putrefaction; which, in my next eſſay, I ſhall endeavour to demonſtrate.

What does the ſea from putrefaction keep?
Should it lie ſtagnant in its ample ſeat,
The ſun would thro' it ſpread deſtructive heat.
The wiſe Contriver, on his end intent,
Careful this fatal error to prevent,
And keep the waters from corruption free,
Mixt them with ſalt, and ſeaſon'd all the ſea.
What other cauſe could this effect produce?
The brackiſh tincture thro' the main diffuſe?
You, who to ſolar beams this taſk aſſign,
To ſcald the waves, and turn the tide to brine,
Reflect, that all the fluid ſtores, which ſleep
In the remoteſt caverns of the deep,
Have of the briny force a greater ſhare,
Than thoſe above that meet the ambient air.
Others, but oh how much in vain, erect
Mountains of ſalt, the ocean to infect.
Who, vers'd in nature, can deſcribe the land,
Or fix the place on which thoſe mountains ſtand?
Why have thoſe rocks ſo long unwaſted ſtood,
Since, laviſh of their ſtock, they through the flood,
Have, ages paſt, their melting cryſtals ſpread,
And with their ſpoils the liquid regions fed?

LIX. FURTHER REFLECTIONS ON THE OCEAN.

> And thou, majeſtic main!
> A ſecret world of wonders in thyſelf!
> Sound His ſtupendous praiſe, whoſe greater voice
> Or bids you roar, or bids your roarings fall.
>
> THOMSON.

In my preceding paper I obſerved, that the ſaltneſs of the ſea can by no means be conſidered as a principal cauſe in preſerving its waters from putrefaction. The ocean has its currents, like rivers, which circulate its contents round the globe; and theſe may be ſaid to be the great agents that keep it ſweet and wholeſome. Sir Robert Hawkins, one of our moſt enlightened navigators, gives an account of a calm, in which the ſea continuing for ſome time without motion, began to aſſume a very formidable appearance. "Were it not (ſays he) for the moving of the ſea, by the force of winds, tides, and currents, it would corrupt all the world. The experiment of this I ſaw in the year 1590, lying with a fleet about the iſlands of Azores, almoſt ſix months; the greateſt part of which time we were becalmed. Upon which all the ſea became ſo repleniſhed with various ſorts of gellies, and forms of ſerpents, adders, and ſnakes, as ſeemed wonderful; ſome green, ſome black, ſome yellow, ſome white, ſome of divers colours, and many of them had life; and ſome there were a yard and a half, and two yards long; which had I not ſeen, I could hardly have believed. And hereof are witneſſes all the companies of the ſhips which were then preſent; ſo that hardly a man could draw a bucket of water clear of ſome corruption. In which voyage, toward the end thereof, many of every ſhip fell ſick, and began to die apace. But

the ſpeedy paſſage into our country, was a remedy to the crazed, and a preſervative for thoſe that were not touched".

This ſhows, ſufficiently, how little the ſaltneſs of the ſea is capable of preſerving it from putrefaction. Mr. Boyle, moreover, once kept a quantity of ſea water, taken up in the Engliſh channel, for ſome time, barrelled up; and, in a few weeks, it began to acquire a fetid ſmell. He was alſo aſſured by one of his acquaintance, who had been becalmed, for about fourteen days, in the Indian ocean, that the water, for want of motion began to ſtink; and, that had the calm continued much longer, the ſtench would probably have poiſoned him. It is the motion, therefore, and not the ſaltneſs of the ſea, that preſerves it in its preſent ſtate of ſalubrity; and this, very probably, as I have lately obſerved by daſhing and breaking in pieces the rudiments, if I may ſo call them, of the various animals, that would otherwiſe breed and putrefy in the ſea.

The ſaltneſs of the ſea, however, is not unproductive of ſome advantages. Its waters, being evaporated, furniſh that ſalt which is uſed for domeſtic purpoſes; and although, in ſome places, it is made from ſprings, and, in others, dug out of mines, yet, the greateſt quantity is made only from the ſea. That which is called Bay ſalt, is a ſtronger kind, made in warm climates, ſuch as Italy, Spain, and the ſouthern provinces of France, by evaporation in the ſun: that called common ſalt, is made by evaporation in pans over the fire, and is of a much inferior quality to the former.

Another benefit ariſing from the quantity of ſalt diſſolved in the ſea, is, that it thus becomes heavier, and, conſequently, more buoyant. Mr. Boyle, who examined the difference between ſea water and freſh, found that the former appeared to be about a forty-fifth part heavier than the latter. Thoſe perſons al-

so, who have had opportunities of bathing in the sea, pretend to have experienced a much greater degree of ease in swimming there, than in fresh water. However, as we see that they have only a forty-fifth more of their weight sustained by it, I am inclined to doubt, whether so minute a difference can be practically perceptible. Be this as it may, as sea water alters in its weight from fresh, so also it is found to differ from itself in different parts of the ocean. In general, it is perceived to be heavier, and consequently, salter, the nearer we approach the line [a].

There is one question, concerning the saltness of the sea, which does not yet appear to be decided; namely, whether it be heavier at the surface, or at the bottom. Mr. Boyle found, that equal bulks of water taken up in the English channel at the surface, and at the depth of fifteen fathoms, were equally heavy, and hence he concludes, that the superficial water was as salt as that at a great depth.

On the other hand, count Marsigli obtained by evaporating the water, a thirty-second part only of its weight of salt from water, taken up on the surface of the sea in the gulf of Lyons, while that taken up at the same time and place, from a great depth, gave him a twenty-ninth part of its weight of salt; and he thence infers, the greater saltness of the sea at the bottom than at its surface. In this conclusion he has been supported by experiments made in the gulf of Bothnia.

There can be no reason to suspect the accuracy with which any of these experiments was made: in different places the facts will probably be different.

[a] It appears from some experiments formerly made in a voyage from Bombay to the East Indies, that the weight of the sea water was the greatest, not precisely at the equator, but where the sun was vertical, and, consequently, in similar circumstances, where the heat was greatest. *Watson's Chem. Essays, vol.* ii. *page* 114.

The river Rhone discharges much fresh water into the gulf of Lyons: this fresh water being lighter than the sea water, will not readily mix itself with it, and for this reason the superficial water will be most diluted by it, and from that circumstance will contain less salt, in a definite quantity, than the water which is at a greater depth. At Northwich they pump their brine, which is to be boiled into salt, into a very large circular basin, sunk in the ground, and lined with brick, from which, when its impurities are subsided, it is conveyed to the boiling pans. This basin is exposed to the open air, and in case of a great fall of rain or snow, they let off the uttermost parts of the water through a wooden tube, which is at other times stopped with a plug, placed upon a level, nearly, with the upper surface of the brine in the basin; what is thus let off is not preserved, but thrown away as useless. This practice proceeds upon the principle I am speaking of, namely, that fresh water is not apt to mix itself, unless it be much agitated, with salt water. The gulf of Bothnia receives rivers from an immense range of mountains, extending themselves to the east, the north, and the west, far beyond the polar circle; and therefore, as in the gulf of Lyons, its surface may be more diluted with fresh water than its middle or bottom. But in the water of the English channel, with which Mr. Boyle made his experiment, the case is very different. This water has a communication with the German ocean on one side, and with the Atlantic on the other; and, from that circumstance, it is subject to such a constant agitation, as will occasion all the fresh water, poured into it by the Thames and Medway, and other rivers of less consequence, to be uniformly diffused through all its substance, so as to render it equally salt at all depths. The constant effect produced on the superficial water of the sea, by the in-

flux of a large river, is ſomewhat ſimilar to the temporary effect, attending a downfall of rain; the ſuperficial water will be thereby much diluted. It has been obſerved, that if a quantity of ſea water in dry weather weighed 778 grains, an equal quantity immediately after a fall of rain would not weigh above 676 grains, the ſame quantity of Thames water weighing 659 grains. Hence it may be collected, that the weight of a cubic foot of the ſea water before rain exceeded the weight of a cubic foot after rain by 155 ounces.

In the open ſea off Shetland, north latitude 60 degrees, equal quantities of water were taken up at the ſurface, and at the depth of ſixty-five fathoms; theſe different waters yielded by evaporation equal quantities of ſalt, namely, nearly one twenty-ninth of their weight.

On another occaſion, in north latitude 65 degrees, ſome water taken up from the ſurface gave nearly one twenty-eighth of its weight of ſalt, while an equal weight taken up from the depth of 683 fathoms, in the ſame place, gave only one thirty-ſecond [a].

It is obvious, that the firſt of theſe experiments confirms Mr. Boyle's notion of the ſea being equally ſalt at all depths, and that the ſecond is wholly oppoſite, both to his opinion, and that of count Marſigli, ſo that the queſtion remains ſtill undecided. There is a circumſtance, however, which, perhaps, may be ſufficient to explain the different reſults of the laſt two experiments. The experiments which gave equal quantities of water, taken up at the depth of 65 fathoms, were made on the twelfth of June; the others, which gave more ſalt from the ſuperficial, than from the deep-water, were made on the fourth of September. Now admitting the ſalt-

[a] Voyage toward the North Pole, in 1773.

neſs of the ſuperficial water, and of water at the depth of 683 fathoms to have been the ſame, in the beginning of June, why may not the quantity of water, evaporated from the ſurface of the ſea, during the hot months of July and Auguſt, have left the ſuperficial water more impregnated with ſalt than the water at a great depth! It is ſome confirmation of this notion, that the air in June was only ſix degrees warmer than the water from the depth of 65 fathoms, and that the air in September, when the experiment was made, was above ſeventy-ſix degrees hotter than the water from the depth of 683 fathoms. The riſe of freſh ſprings at the bottom of the ſea, in particular places, may be another reaſon for our accidentally finding the ſea ſalter at its ſurface than at any great depth below it. However, neither of the reaſons here offered in explanation of the phenomenon are wholly to be relied on; for the freſh water which may accidentally be found at the bottom of the ſea will riſe up till it becomes as much impregnated with ſalt, as the water incumbent over it is, and the water at the ſurface, which is rendered heavier by the ſun having evaporated ſome of its freſh particles, will probably ſink downward, and mix itſelf with the water below it, till the whole maſs of water becomes equally heavy, and conſequently equally ſalt. The fact itſelf, of the ſea being in any caſe ſalter at the ſurface than at its bottom, ought to be aſcertained by repeated experiments[a].

But leaving this diſcuſſion, which, perhaps, is more curious than uſeful, there is an advantage ariſing from the ſaltneſs of the waters of the ſea much greater than what has been yet mentioned; which is, that the congelation of them is thus retarded. Some, indeed, have gone ſo far as to ſay,

[a] Watſon's Chym. Eſſays, vol. ii. page 120.

that the ſea water never freezes: but this is an aſſertion contradicted by experience. However, it is certain, that it requires a much greater degree of cold to freeze it than freſh water does. It is, therefore, one of the greateſt bleſſings that we derive from this element, that when, at land, all the ſtores of Nature are locked up from us, we find the ſea ever open to our neceſſities, and patient of the hand of induſtry.

It muſt not be ſuppoſed, however, that becauſe we never ſee the ſea frozen in our temperate climate, that it is in the ſame manner open in all parts of our globe. Not to mention, that, at particular ſeaſons, the mouth of the river St. Lawrence, the entrance into the Baltic Sea, &c. &c. are ſo much frozen over as to be impaſſible by ſhips, the vaſt mountains and fields of ice in the polar regions, have, for ages paſt, been inſurmountable obſtructions to the daring reſearches of our ableſt navigators.

Of the origin of ice in the frozen ſeas there are different opinions. Biſhop Watſon has obſerved, upon the authority of captain Weymouth, captain Cook, and lord Mulgrave, that very good freſh water has been made from the ice found in thoſe ſeas; and having ſtated this, he thus proceeds; "Notwithſtanding theſe teſtimonies of our moſt experienced navigators, concerning the freſh water which they procured from the thawing of the ice, they found floating in the ſea; yet it might ſtill remain a matter of doubt, whether the ice, from which the water was obtained, had been formed in the ſea, and conſequently, whether ſea water itſelf would when frozen yield freſh water. For it might, with ſome appearance of probability, be ſaid, that the ice had either been formed at the mouths of large freſh water rivers, and thence by tides or torrents drifted into the ſea; or that it had been broken by its own weight, from

the immenſe cliffs of ice and frozen ſnow, which, in countries where there are few rivers, are found in high latitudes to project a great way into the ſea [a]; or laſtly, admitting it to be formed in the ſea, it might be urged, that it was formed of freſh water, not of ſalt. Fotherbye, in his voyage in 1614, eſteems ſnow the original cauſe of the ice found at ſea, for he obſerved it to be an inch thick upon the ſurface of the ſea; and captain Cook, from his own obſervations in the South Sea, was diſpoſed to think, that the vaſt floats of ice he met with in the ſpring, were formed from the congelation of ſnow [b]. Without doubt, the ſnow which falls upon the ſurface of the ſea, being in a ſolid ſtate, and, bulk for bulk, lighter than the ſea water, will not readily mix itſelf with it but may, by a due degree of cold in the atmoſphere, be ſpeedily converted into a layer of ice: the upper ſurface of this firſt layer of ice, being elevated above the ſurface of the ſea, will receive all the freſh water which falls from the atmoſphere in the form of ſnow, ſleet, rain, or dew; by the ſucceſſive congelation of which, the largeſt fields of ice may at laſt be formed. Whether the ice found at ſea, be formed according to any one or all of theſe ways, it is evident, that it is produced from an accumulation of congealed freſh water, and that we cannot, from the freſh water procurable from ice thus formed, conclude that the ice of frozen ſea water would yield freſh water.

"To a navigator, it is a matter of little conſequence to determine, whence the ice which ſupplies him with freſh water is produced: he is ſure of

[a] *Icebergs* are large bodies of ice filling the vallies between the high mountains.—Large pieces frequently break off from the icebergs, and fall with great noiſe into the water: we obſerved one piece, which had floated out into the bay, and grounded in twenty-four fathom; it was fifty feet high above the ſurface of the water. Phipps' Voyage, page 70.

[b] Voyage toward the South Pole, vol. ii. page 242.

meeting with more than enough of it for his purpose, and he leaves it to the leisure of philosophers to decide the question, whether congealed sea water will, when thawed, yield fresh water. They have decided it by actual experiments, made with every suitable attention. Some sea water was taken up off the North Foreland, it was exposed to a freezing atmosphere, and it afforded an ice perfectly free from any taste of salt". The bishop then, after mentioning some furthur experiments to the same effect, thus continues: " It had been long ago asserted by Macrobius, that sea water was never frozen, but that the ice found at sea, proceeded from the freezing of the fresh water spread over its surface by the influx of rivers. And in modern times, the opinion, concerning the freezing of sea water, seems to have been admitted with great caution, by our most experienced navigators. They were aware, indeed, that the Baltic and other large seas, were frequently frozen quite over, but they appear to have thought, that falls of snow laid a sufficient foundation for the production of that event, ' without its being at all necessary for the sea water to freeze'. I cannot conceive that there was any great occasion for this cautious mode of expression, since it had been observed, above a hundred years ago, that not only sea water, but water containing double the proportion of salt commonly found in our sea water, and more than is contained in the sea water of any climate, might be frozen by the cold prevailing in our atmosphere".

A very eminent naturalist, who admits the congelation of sea water, has presented us with a very striking description of the wonderful phenomenons which the mountains of ice exhibit in these regions of desolation. But as I have already availed myself

a Cook's Voyage, vol. ii. page 242.

of this deſcription in my paper On Winter in the Polar Regions [a], I need not repeat it here.

The tides, the ſaltneſs of the ſea, and mountains of ice, which I have thus deſcribed, are not the only phenomenons obſervable in the wonderful world of waters. But I cannot, in this paper, enter into the diſcuſſion of any other.

LX. CONCLUSION OF REFLECTIONS ON THE OCEAN.

They that go down to the ſea in ſhips, that do buſineſs in great waters; theſe ſee the works of the Lord, and his wonders in the deep. PSALMS.

There are yet hid greater things than theſe be, for we have ſeen but a few of his works. We may ſpeak much, and yet come ſhort; wherefore, in ſum, He is all. ECCLUS.

THE works of nature can excite ſenſations of pleaſure, even in minds the leaſt habituated to reflection. Such, however, are content with mere exterior beauty, and extend not their reſearches beyond the ſurfaces of things. The vaſt expanſe of waters appears to them in two aſpects only; as an object of dreadful ſublimity in a ſtorm, or of pleaſing magnificence in a calm. But the Contemplative Philoſopher extends his view far beyond the diſtant horizon, and far below the agitated ſurface. He conſiders the ocean, with the Son of Sirach, as the immenſe receptacle of wonders yet undiſcovered, and of phenomenons, which, perhaps, will continue ever unexplained.

[a] No. IV.

There is one very curious phenomenon in the ocean, which has long exercised the sagacity of philosophers. This is the luminous appearance of its surface during the obscurity of the night. M. Bayon, surgeon-major at Cayenne, made a great number of experiments, at different seasons, in order to find out the true cause of this phenomenon; and it always appeared to him, that these luminous points were produced by friction alone. Though he often made use of the best glasses, he could never perceive any insect; and, therefore, he is inclined to think, that these luminous points are rather the effects of motion and friction than of animal bodies, as has been supposed by some philosophers [a]. But from the experiments and observations of many learned men [b] on this subject, as far backward as Bacon and Boyle, it appears evident, that various causes, both jointly and separately, produce this phenomenon. The experiments of Mr. Canton [c] prove, that the putrefaction of animal substances produces light and scintillation in the sea. A little white fish placed in sea-water rendered it luminous in the space of twenty-eight hours; and certain quantities of salt, and oil of hartshorn, are known to produce a similar effect in common water. On the other hand, it is certain, that there is in the sea a prodigious quantity of shining insects or animalcules, which contribute to this phenomenon. M. Dagelet, a French astronomer, who returned from Terra Australis in 1774, brought with him several kinds of worms, which shine in water, when it is set in motion; and M. Rigaud

[a] Memoires pour servir à l'histoire de Cayenne et de la Guianne Francoise.

[b] Particularly Ozanum, in his treatise concerning Phosphori; Bartholin, in his Differt. de Luce Animalium; Donati, in his History of the Adriatic Sea; Nollet, in the Memoirs of the Royal Academy of Sciences for 1750; and Vianelli, in his Nuove Scoperte intorno le Luci nottorno dell' Aqua Marina.

[c] Philos. Trans. 1769.

affirms, that the luminous ſurface of the ſea, from Breſt to the Antilles, contains an immenſe quantity of little, round, ſhining polypuſes, of about a quarter of a line in diameter [a]. Other learned men, who acknowledge the exiſtence of theſe luminous animals, cannot, however, be perſuaded to conſider them as the cauſe of all that light and ſcintillation which appear on the ſurface of the ocean. They think that ſome ſubſtance of the phoſphorus kind, ariſing from putrefaction, muſt be admitted as one of the cauſes of this phenomenon. M. Godehoue has publiſhed curious obſervations on a kind of fiſh, called in French *bonite*, and reſembling the tunny, in which there is an oil which ſhines with a conſiderable luſtre; and, although he has obſerved, and accurately deſcribed, ſeveral of the luminous inſects that are found in ſea-water, he is, nevertheleſs, of opinion, that the ſcintillation and flaming light of the ſea proceed from the oily and greaſy ſubſtances with which it is impregnated.

Abbé Nollet was long of opinion, that the light of the ſea proceeded from electricity; but he afterward ſeemed inclined to think, that this phenomenon was cauſed by ſmall animals, either by their luminous aſpect, or, at leaſt, by ſome liquor, or effluvia, which they emitted; he did not, however, exclude other cauſes: among theſe, the ſpawn or fry of fiſh deſerves to be noticed. M. Dagelet, ſailing into the bay of Antongil, in the iſland of Madegaſcar, obſerved a prodigious quantity of fry, which covered the ſurface of the ſea above a mile in length, and which he, at firſt, on account of their colour, took for banks of ſand. They exhaled a diſagreeable odour, and the ſea had appeared with uncommon ſplendour ſome days before. The ſame accurate obſerver, perceiving the ſea remarkably luminous in

[a] Journal des Savans 1770.

the road of the Cape of Good Hope, during a perfect calm, remarked, that the oars of the canoes produced a whitiſh and pearly kind of luſtre: when he took in his hand the water which contained phoſphorus, he diſcerned in it, for ſome minutes, globules of light as large as the heads of pins. When he preſſed theſe globules, they appeared to his touch like a ſoft and thin pulp; and ſome days after the ſea was covered, near the coaſts, with whole banks of theſe little fiſh, in innumerable multitudes.—In a word, it is probable, as obſerved before, that various cauſes contribute to the ſight and ſcintillation of the ſea; and that the light which M. Bayon attributed to agitation and friction, is different from that which is extended far and near, which ſeems to cover the whole ſurface of the ocean, and produces a very ſtriking and beautiful appearance, particularly in the torrid zone, and in the ſummer ſeaſon.

The revolutions produced upon the earth by the ſea, form another object of contemplation. It is every day making conſiderable alterations, either by overflowing its ſhores in one place, or deſerting them in others; by covering over whole tracts of country, that were cultivated and peopled at one time; or by leaving its bed to be appropriated to the purpoſes of vegetation, and to ſupply a new theatre for human induſtry, at another.

In this ſtruggle for dominion between the earth and the ſea, the greateſt number of our ſhores ſeem to defy the whole rage of the waves, both by their height, and the rocky materials of which they are compoſed, which defend the land, and are only interrupted here and there, to give an egreſs to rivers, and to afford to our ſhipping the conveniencies of bays and harbours. In general, it may be remarked, that wherever the ſea is moſt furious, there the boldeſt ſhores, and of the moſt compact materials, are found to oppoſe it. There are many ſhores ſe-

veral hundred feet perpendicular, against which, the sea, when swoolen with tides or storms, rises and beats with inconceivable rage.

Hence, therefore, we may conceive, how the violence of the sea, and the boldness of the shore, may be said to have made each other. When the sea meets no obstacles, it swells its waters with a gentle intumescence, till all its power is destroyed, by wanting depth to aid its motion. But when its progress is checked in the midst, by the prominence of rocks, or the abrupt elevation of the land, it dashes with all the force of its depth against the obstacle, and forms, by its repeated violence, the abruptness of the shore which confines its impetuosity. Where the sea is extremely deep, or very much agitated by tempests, it is no small obstacle that can confine its rage; and for this reason we see the boldest shores projected against the deepest waters; all smaller impediments having long before been surmounted and washed away. Perhaps, of all the shores in the world, there is not one so high as that on the west of St. Kilda, which is 600 fathoms perpendicular above the surface of the sea. Here, also, the sea is deep and stormy: so that it requires great force in the shore to oppose its violence. In many parts of the world, and particularly in the East Indies, the shores, though not high above water, are generally very deep, and, consequently, the waves roll against the land with great weight and irregularity. This rising of the waves against the shore, is called the surf of the sea, and, in shipwrecks, is generally fatal to such as attempt to swim on shore. In this case, no dexterity in the swimmer, no float he can use, neither swimming girdle nor cork jacket will save him: the weight of the superincumbent waves breaks upon him at once, and crushes him with certain ruin. Some few of the natives, however, have the art of swimming, and of navigating their little boats

near theſe ſhores, where an European is ſure of immediate deſtruction.

In places where the force of the ſea is leſs violent, or its tides leſs rapid, the ſhores are generally ſeen to deſcend with a more gradual declivity. Over theſe, the waters of the tide ſteal by almoſt imperceptible degrees, covering them for a large extent, and leaving them bare on its receſs. Upon theſe ſhores, as I have obſerved, the ſea ſeldom beats with any great violence, as a large wave has not depth ſufficient to float it onward; ſo that here are to be ſeen gentle ſurges only, making calmly toward land, and leſſening as they approach. As the ſea, in the former deſcription, is generally ſeen to preſent proſpects of tumult and uproar, here it more uſually exhibits a ſcene of repoſe and tranquil beauty. Its waters, which, when ſurveyed from the precipice, afforded a muddy greeniſh hue, ariſing from their depth and poſition to the eye[a], when beheld from a ſhelving ſhore, are the colour of the ſky, and ſeem riſing to meet it. The deafening noiſe of the deep ſea, is here converted into gentle murmurs; and, inſtead of the water daſhing againſt the face of the rock, it advances and recedes, ſtill going forward, but with juſt force enough to puſh its weeds and ſhells, by inſenſible approaches to the ſhore.

There are other ſhores, which have been either raiſed by art to oppoſe the inroads of the ſea, or, from its gaining ground, are menaced by immediate deſtruction. The ſea being thus ſeen to give and take away lands at pleaſure, is, without queſtion, one of the moſt extraordinary conſiderations in natural hiſtory. In ſome places, it is ſeen to obtain the ſuperiority by ſlow and certain approaches; or to burſt in at once, and overwhelm all things in undiſtinguiſhed deſtruction: in other places, it departs from

[a] Newton's Optics.

its ſhores, and where its waters have been known to rage, it leaves extenſive fields covered with verdure.

The formation of new lands, by the ſea continually bringing its ſediment to one place, and by the accumulation of its ſands in another, is eaſily conceived. Many inſtances of this are recorded, which I have not room to recapitulate. One alone will ſuffice: the whole republic of Holland ſeems to be a conqueſt from the ſea, and to be reſcued, in a manner, from its boſom. The induſtry of man, however, in the formation of dikes, muſt here be mentioned; for the ſurface of the earth, in this country, is ſtill below the level of the ſea.

But as the ſea has been known to recede from ſome lands, ſo it has, by fatal experience, been known to encroach upon others; and, probably, theſe depredations on one ſhore, may account for its dereliction of another: for the current which reſted upon ſome certain bank, having got an egreſs in ſome other place, no longer preſſes upon its former bed, but pours all its ſtream into the new entrance; ſo that every inundation of the ſea may be attended with a correſpondent dereliction of another ſhore.

However this be, we have numerous inſtances of the inundations of the ſea, and of its burying whole provinces in its boſom. One of the moſt conſiderable of theſe, is that which happened in the reign of Henry I, which overflowed the eſtates of earl Godwin, in Kent, and formed that celebrated bank, called the Godwin Sands.

There are ſome ſhores on which the ſea has made temporary depredations; where it has overflowed, and, after remaining, perhaps, ſome ages, has again retired of its own accord, or been driven back by the induſtry of man. The country round the Iſle of Ely, in the time of Bede, about ten centuries ago, was one of the moſt delightful ſpots in the kingdom.

It was not only richly cultivated, and produced all the neceſſaries of life, but grapes alſo, that afforded excellent wine. The accounts of that time are copious in the deſcription of its verdure and fertility; its rich paſtures, covered with flowers and herbage; its beautiful ſhades and wholeſome air. But the ſea breaking in, overwhelmed the whole country, and totally deſtroyed one of the moſt fertile vallies in the world. Its air, from being dry and healthful, from that time became very unwholeſome; and the ſmall part of the country, that, from being higher than the reſt, eſcaped the deluge, was ſoon rendered uninhabitable, from its noxious vapours. This country continued thus under water for ſome centuries; till the ſea, at laſt, by the ſame caprice which had prompted its invaſion, began to abandon it, and has continued, for ſome ages, to relinquiſh its former conqueſts.—Of inundations of the like kind, concerning which hiſtory has been ſilent, we have numberleſs teſtimonies of another nature, that prove it beyond the poſſibility of doubt: I mean thoſe numerous trees, that are found buried at conſiderable depths, in places which the ſea, or rivers, have accidentally overflowed.

But the influence which the ſea has upon its ſhores, is nothing to that which it has upon that great body of earth which forms its bottom. It is at the bottom of the ſea that the greateſt wonders are performed, and the moſt rapid changes produced. It is there that the motions of the tides and currents have their whole force, and agitate the ſubſtances of which their bed is compoſed. But theſe are almoſt wholly hidden from human curioſity: the miracles of the deep are performed in ſecret; and we have but little information from its abyſſes, except what we receive by inſpection at very ſhallow depths, or by the plummet, or from divers, who are known to deſcend from twenty to thirty fathoms.

The eye can reach but a very ſhort way into the depth of the ſea; and that only when its ſurface is glaſſy and ſerene. In many ſeas, it perceives nothing but a bright ſandy plain at bottom, extending for ſeveral hundred miles, without an intervening object. But, in others, particularly in the Red Sea, it is very different. the whole body of this extenſive bed of water is, literally ſpeaking, a foreſt of ſubmarine plants, and corals formed by inſects for their habitation, ſometimes branching out to a great extent. Here are ſeen the madrepores, the ſponges, moſſes, ſea-muſhrooms, and other marine productions, covering every part of the bottom.—The bed of many parts of the ſea, near America, preſents a very different, though a very beautiful appearance. This is covered with vegetables, which make it look as green as a meadow; and, beneath, are ſeen thouſands of turtles, and other ſea-animals, feeding thereon.

The wonders of the great deep are ſtill inexhauſtible, if we enter into other extenſive ſubjects that have a cloſe connection with it, ſuch as zoology and navigation. As theſe, however, form ſubjects that ſhould be treated under other heads, I ſhall conclude this paper, by preſenting my readers with ſome pertinent reflections, by the celebrated M. Savary, in his inſtructive and entertaining Letters on Greece.

"We enjoy the fineſt weather imaginable; not a cloud obſcures the ſky, and a ſoutheaſt wind wafts us directly toward the port to which our wiſhes tend. We have now entirely loſt ſight of land, and, as far as the eye can reach, only view the immenſe abyſs of the waters, and the vaſt expanſe of the heavens. How awful is this ſight! How does it inſpire the mind with great ideas! How adventurous is man, who truſts his fortune and his life to this frail veſſel he has built, which a worm may pierce, or a ſingle blaſt daſh to pieces againſt a rock. Yet in this he

braves the fury of the ocean! But how admirable is his ingenuity! He commands the winds, enchains them in the canvas, and forces them to conduct him where he pleaſes. He ſails from one end of the world to the other, and traverſes the immenſe liquid plains, without any ſignals to direct him. He reads his courſe in the heavens. A needle, which wonderfully points perpetually to the pole, and the obſervation of the ſtars, inform him where he is. A few lines and points mark out to him the iſlands, coaſts, and ſhoals, which his ſkill enables him to approach or avoid at pleaſure. Yet has he cauſe to tremble, notwithſtanding all his ſcience and all his genius! The fire of the clouds is kindling over his head, and may conſume his dwelling. Unfathomable gulfs are yawning beneath his feet, and he is ſeparated from them only by a ſingle plank. His confidence might make us imagine he knew himſelf immortal; yet he muſt die—die never to revive again"!

LXI. ON THE DECAY AND FALL OF THE LEAVES.

How ſweetly pleaſing to behold
Foreſts of vegetable gold!
How mix'd the many chequer'd ſhades between
The tawny mellowing hue, and the gay vivid green!

FAWKES.

Quam multà in ſylvis Autumni frigore primo
Lapſa cadunt folia. VIRGIL.

Thick as autumnal leaves that ſtrow the brooks,
In Vallombroſa, where th' Etrurian ſhades
High over-arch'd imbower. MILTON.

EACH ſeaſon of the revolving year produces a variety of pictureſque appearances peculiar to itſelf. The emotions which affect the mind, while it contemplates ſcenes which every month contributes to diverſity, muſt conſequently be of various kinds, all ſuitable to the ſeaſon. The vivid beauties of Spring, the glowing ſkies of Summer, the fading ſcenes of Autumn, and the dreary aſpect of Winter, excite reſpectively, vivacity, languor, ſolemnity, or dejection.

Summer, refulgent "Child of the Sun" retires, with "his ardent look", from our northern regions, in the month of September. Each gaudy flower diſappears, and Winter approaches faſt. But the gloom of the falling year is in ſome meaſure enlivened in that month eſpecially, by the variety of colours, ſome lively and beautiful, which are then aſſumed by the fading leaves of trees and ſhrubs.

Thoſe virgin leaves of pureſt vivid green,
Which charm'd ere yet they trembled on the trees,
Now cheer the ſober landſcape in decay;

The Lime first fading; and the golden Birch,
With bark of silver hue; the moss-grown Oak,
Tenacious of its leaves of russet brown;
Th'ensanguin'd Dogwood, and a thousand tints
Which Flora, dress'd in all her pride of bloom,
Could scarcely equal, decorate the groves.

What a beautiful description is this, of the appearance which some of the trees, in particular, are observed to exhibit! But the great poet of the Seasons, with comprehensive eye, extends his view, and describes the diversified aspect of the changing woods, in one magnificent landscape far diffused around.

The fading many-coloured woods,
Shade deep'ning over shade, the country round
Imbrown; a crowded umbrage, dusk and dun,
Of every hue, from wan-declining green
To sooty dark. These now the lonesome Muse,
Low whispering, lead into their leaf-strown walks,
And give the season in its latest view.

From the gradual change and decay of the leaf, we are next invited to contemplate its fall. This last circumstance is so striking, that the whole declining season of the year is often, in common language, called the fall. Here Thomson again presents us with a prospect. What he had before described, the general aspect of the woods, was obvious, perhaps, to every admirer of Nature. But what poet had ever before described so minute a circumstance as the effect which the falling leaf often has upon the contemplative mind?

Now the leaf
Incessant rustles thro' the mournful grove;
Oft startling such as studious walk below,
And slowly circles thro' the waving air.
But should a quicker breeze, amid the boughs
Sob, o'er the sky the leafy deluge streams:
Till choak'd, and matted with the dreary shower,

The foreſt walks, at every riſing gale,
Roll wide the withered waſte, and whiſtle bleak.
Fled is the blaſted verdure of the fields;
And, ſhrunk into their beds, the flowery race
Their ſunny robes reſign. Ev'n what remain'd
Of ſtronger fruits, falls from the naked tree;
And woods, fields, gardens, orchards, all around
The deſolated proſpect thrills the ſoul.

Abbé de Lille in his beautiful didactic poem, *Les Jardins*, has likewiſe been very happy in deſcribing the variegated appearance of the woods, and the philoſophic emotions which this viciſſitude of Nature has a tendency to inſpire. The fine effect of the falling leaf he has evidently borrowed from Thomſon:

Que de varieté, que de pompe et d'éclat!
Le pourpre, l'orangé, l'opale, l'incarnat,
De leurs riches couleurs étalent l'abondance.
Helas! tout cet éclat marque leur decadence.
Tel eſt le ſort commun. Bientôt les aquilons
Des dépouilles des bois vont joncher les vallons;
De moment en moment la feuille ſur la terre,
En tombant, interrompt le rêveur ſolitaire.
Mais ces ruines même ont pour moi des attraits.
Là, ſi mon cœur nourrit quelques profonds regrets,
Si quelque ſouvenir vient rouvrir ma bleſſure,
J'aime à mêler mon deuil au deuil de la Nature.
De ces bois deſſéchés, de ces rameaux flétris,
Seul, errant, je me plais à fouler les débris.
Ils ſont paſſés les jours d'ivreſſe et de folie;
Viens, je me livre à toi, tendre Melancolie;
Viens, non le front chargé des nuages affreux
Dont marche enveloppé le Chagrin ténébreux,
Mais l'œil demi-voilé, mais telle qu'en Automne
A travers des vapeurs un jour plus doux rayonne:
Viens, le regard penſif, le front calme, et les yeux
Tout prêts à s'humecter de pleurs delicieux. Chant ii.

What pomp, what vaſt variety of hues
The woodland ſcenes adorn. The purple deep,

Orange, and opal, and carnation bright,
To the rapt eye their rich profusion spread.
Alas! this splendour all bespeaks decay.
Such is the common lot. The north winds soon
Their sylvan spoils will strow along the vales.
The leaf incessant flutters to the ground,
And, flutt'ring, startles such, who musing stray,
Lonely and devious through the solemn shades.
Yet have these leafy ruins charms for me.
There, should my heart some poignant woe conceal,
And sad Remembrance ope the bleeding wound,
How sweet to mingle then my sorrowing gloom,
With the deep gloom that saddens all the scene!
Wand'ring, recluse, how sweet to tread the spoils
Of the stripp'd woods and wither'd branches round!
The giddy days of gay aspiring Hope,
And all my youthful follies, now are fled.
Come then, O soothing Melancholy, come;
To thee each moment I devote: But come,
Not o'er thy visage hov'ring frightful clouds,
Involv'd in which depressing Sorrow walks,
But with eye half-veil'd, as in Autumn when
Through congregated fogs a brighter sun
With sudden radiation cheers the day:
O come, with pensive look, and front serene,
While the big drops sit trembling in thine eye,
Or steal adown thy cheek delicious tears.

Such are the appearances and effects which result from the gradual decay and fall of the leaves. But the Contemplative Philosopher, not content with general appearances and effects, delights to explore with curious eye, their latent cause. And when he examines the structure of the leaves of trees, and inquires into their uses, with what a grateful heart must he acknowledge, that the all-wise Creator has not designed them for ornament only, but for the most important service in vegetation.

Botanists define a leaf to be a part of a plant extended into length and breadth, in such a manner as

to have one ſide diſtinguiſhed from the other. They are properly the extreme part of a branch, and the ornament of the twigs. They conſiſt of a very glutinous matter, being furniſhed every where with veins and nerves. Of the different diſtinctions of leaves, according to their poſition and form, above one hundred are enumerated. In all of them, one of the offices is to ſubtilize and give more ſpirit to the abundance of nouriſhing ſap, and to convey it to the little buds.

There are two orders of veins and nerves in leaves, one belonging to each ſurface; and it has been generally obſerved, that the lower lamina, or under ſide of the leaf, has the ramifications larger, and is capable of admitting a liquid to paſs through them, which thoſe of the upper ſurface will not. Theſe two orders of veins are inoſculated at ſeveral places; but not ſo cloſely connected, but that they may be eaſily ſeparated, after they have been ſteeped in water a proper time. Both, it is ſuppoſed, are deſtined for very different purpoſes. The upper lamina, or coat of veins, is thought to conſiſt of air-veſſels, through which the perſpiring matter is protruded, and by which the air is inſpired. This is evident from the clamy ſubſtance called honey-dew, which is always found ſticking on the upper ſurface of leaves. The lower lamina is ſuppoſed to be intended for the receiving, preparing, and conveying the moiſture, imbibed from the riſing vapours of the earth, by which trees and plants are greatly nouriſhed: ſo that one principal uſe of leaves is to perform, in ſome meaſure, the ſame office for the ſupport of vegetable life, as the lungs of animals do for the ſubſiſtence of animal life. For theſe reſpective uſes the two ſurfaces are very differently formed. The upper part is commonly ſmooth and lucid; the under one frequently covered with hairs, or a ſoft down, the better to ſtop and detain the

rising vapours, and transmit them to the inner vessels. Where the structure of the leaves is different, it has been demonstrated by experience that their functions alter; for in those leaves whose upper surface is furnished with down or hairs, that upper surface is found to be the receiver and conveyer of the moisture, and not the under one, as in the other plants. If the surface, therefore, of these be altered, by reversing the branches on which they grow, the plants are stopped in their growth until the foot-stalks are turned, and the leaves restored to their former position.

Another of the great functions for which the leaves of trees and plants are designed, is that of their foot-stalks nourishing and preparing the buds of the future shoots, which are always formed at the base of these foot-stalks. During the continuance of the leaves in perfect health, these buds increase in magnitude, and, in the deciduous trees, are brought to maturity before the foot-stalks separate from the buds in Autumn. If the leaves be blighted, or their entire surface cut, although the foot-stalks remain, yet the buds will decay, or not arrive at their proper size, for want of the nourishment which is conveyed to them from the leaves. Whenever, therefore, the trees are divested of their leaves, or those leaves are cut, or otherwise impaired, although it happen in either case when the buds are nearly formed, yet, if it be before the foot-stalks separate naturally from the branches, the future shoots will be weakened in proportion to the time when this is done. In a word, it is of the utmost consequence not to pull or cut off the leaves of trees or plants, while they retain their verdure, and are in health.

Leaves, moreover, are designed to shade the buds for the future shoots from the sun, which would otherwise exhale and dry up all their moisture. They also shade the young fruit, which is abso-

lutely neceſſary, during the time of their growth. They throw off, by tranſpiration, what is unneceſſary to the growth of the plant; and this correſponds to the diſcharge which is made by perſpiration in animal bodies. Indeed plants receive and tranſpire much more in equal time than large animals. The ſunflower, for inſtance, has been found, by repeated experiments, to receive and perſpire, in twenty-four hours, ſeventeen times more than a man.

Air evidently paſſes in at the leaves, and goes through the whole plant, and out again at the roots. If the leaves have no air, the whole plant will die. This has been proved by experiments with the air-pump. And plants not only draw through their leaves ſome part of their nouriſhment from the air, but the leaves alſo perform the neceſſary work of altering the water received in at the roots into the nature and juices of the plant; and hence it is that the life of the plants depends ſo immediately on their leaves. The huſbandman often ſuffers for want of this knowledge. A crop of ſaintfoin is a very valuable thing, and its root being perennial, will yield him increaſe many years; but it is often deſtroyed at firſt, by ſuffering it to be indiſcreetly fed upon by the ſheep, which eating up all the leaves, the root remains without the means of a ſupply of air, and the whole plant periſhes. This remark has been likewiſe extended to prove the abſurdity of feeding down wheat in the Winter and Spring.

Leaves being thus ſo neceſſary, Nature has, in all perennial plants, provided a reverſionary ſtock of them. The leaves of theſe plants are always formed in Autumn, though they are not unfolded till the following Spring. They then open and increaſe gradually, in proportion to the motion of the ſap, and the quantity of pabulum, or nouriſhment, it then receives to be circulated. And theſe leaves of evergreens have alſo a thin compact ſkin or cover

over their ſurfaces. They are found by experiment to imbibe and perſpire but little in the ſame ſpace of time, when compared with the deciduous trees and ſhrubs; and it is chiefly owing to this cloſe covering, and to the ſmall proportion of moiſture contained in their veſſels, that they retain their verdure, and continue uninjured in the ſevereſt froſts; a circumſtance which is likewiſe owing to their oily exterior. Beſide theſe autumnal leaves, there is another ſet of them formed in Spring, and expanded about Midſummer. Theſe are of infinite ſervice to many trees, particularly to the mulberry, as they ſave its life when the ſpring-leaves have been all eaten up by the ſilkworms.

No plant, indeed, to which Nature has allotted leaves, can live without them, but will certainly die if they are pulled off as ſoon as they appear. The common graſs of our meadows and paſtures might ſeem an exception to this general rule; but it is to be conſidered, that though the ſheep eat this down very cloſe, and take off its leaves as ſoon as they grow, yet when it is thus devoured by cattle, it is only in the leaf, very little of it growing up into ſtalk at that time; and therefore leſs ſap is to be purified, and conſequently leſs of the operation allotted to the leaves required. There is, beſides, a conſtant ſucceſſion of new leaves growing up in the place of the old ones; and many of theſe being too ſhort to be bitten off, ſerve in the place of thoſe which are eaten.

Finally, the leaf ſerves in a ſingular manner, as already obſerved, to nouriſh the eye or germ of the plant, until, growing by degrees to a greater bulk, it preſſes the veſſels of the foot-ſtalk together, whereby the juice is by little and little ſtopped in the leaf till it cannot any more return through the foot-ſtalk; which, by the ceſſation of the afflux and reflux of the nutritious juice, grows putrid, and the

leaf dies, and falls off. This is the chief cauſe of the fall of the leaf in Autumn. But other cauſes are adduced. One of the moſt obvious is the coldneſs of the ſeaſon; for no ſooner are the leaves covered with the firſt hoar-froſt, than they are obſerved to fall in great abundance, and all the trees and plants are ſtripped of their verdant honours. The cold, it is ſaid, cauſes a ſtagnation of the ſap in plants, and prevents its tranſpiration by the leaves. But this explanation would be inſufficient without the ſolution already given; for the leaves will certainly fall, although it do not freeze during the whole winter; nor can the ſhelter of greenhouſes prevent this annual decay and fall.

But whatever be the cauſe of this viciſſitude in the vegetable reign, the decay and fall of the leaves have been favourite themes with poets and philoſophers. The firſt they furniſh with beautiful deſcriptions; the latter with ſolemn contemplations and pathetic moral ſentiment. There is ſomething, indeed, extremely melancholy in that gradual proceſs by which the trees are ſtripped of all their beauty, and left ſo many monuments of decay and deſolation. Homer, the venerable father of poetry, has deduced from this ſucceſſion of ſpringing and falling leaves, a very appoſite compariſon for the tranſitory generations of men:

Like leaves on trees the race of man is found,
Now green in youth, now withering on the ground.
Another race the following ſpring ſupplies,
They fall ſucceſſive, and ſucceſſive riſe;
So generations in their courſe decay,
So flouriſh theſe, when thoſe are paſt away. POPE.

LXII. ON THE CHAIN OF BEINGS IN THE UNIVERSE.

Look round our world; behold the chain of love
Combining all below and all above. POPE.

Bnt how preſerv'd
The chain unbroken upward, to the realms
Of incorporeal life—thoſe realms of bliſs
Where Death hath no dominion? YOUNG.

ALL the beings in this world, whether animal or vegetable, have a mutual connection and dependence. There is a graduated ſcale or chain of exiſtence, not a link of which, how inſignificant ſoever, could be broken, without affecting the whole. Unthinking men are apt to wonder, for inſtance, at the deſign of Providence in producing certain inſects and reptiles. They do not conſider, that the annihilation of any one ſpecies of theſe creatures, although ſome of them are even noxious to man, would make a blank in the creation, and prove deſtructive to other creatures that feed upon them. Thc deſtruction of theſe, in their turn, would occaſion the deſtruction of other ſpecies; and the ſyſtem of devaſtation would gradually proceed, till man himſelf were extirpated, and the earth left deſtitute of animation.

He, who through vaſt immenſity can pierce,
See worlds on worlds compoſe one univerſe,
Obſerve how ſyſtem into ſyſtem runs,
What other planets circle other ſuns,
What varied being peoples every ſtar,
May tell why Heaven has made us as we are.
But of this frame the bearings and the ties,
The ſtrong connections, nice dependencies,
Gradations juſt, has thy pervading ſoul
Look'd through? Or can a part contain the whole?
POPE.

Man is certainly the chief link in the chain of animals; and all the other links deſcend from him by almoſt imperceptible gradations. As a rational animal, highly improved by ſcience and the arts; and, more particularly, from the capacity of religious knowledge, which, of all the creatures of this world, he alone poſſeſſes; he is, in ſome meaſure, related to Beings of a ſuperior order, wherever they exiſt. By contemplating the works of creation, he riſes to ſome faint idea of its great Author.—But why, it has been aſked, do not men poſſeſs the capacity and powers of angels? With the ſame propriety, it may be aſked, why have not brutes the intellectual faculties of men? Queſtions of this kind proceed from the petulance of ignorance and preſumption. Every creature is perfect, according to its deſtination. Exalt or depreſs any order of beings, the whole ſyſtem, of courſe, would be deranged, and a new world would be neceſſary to contain and ſupport them. Particular orders of beings ſhould not be conſidered ſeparately, but by the rank they hold in the general ſyſtem. From man to the moſt minute animalcule that can be diſcovered by the microſcope, the chaſm ſeems to be infinite: but that chaſm is actually filled up with ſentient beings, of which the lines of diſcrimination are almoſt imperceptible; and all of them are endued with certain degrees of perfection proportioned to their reſpective ſtations in the univerſe.

See, thro' this air, this ocean, and this earth,
All matter quick, and burſting into birth.
Above, how high progreſſive life may go!
Around, how wide! how deep extend below!
Vaſt chain of being! which from God began,
Natures ethereal, human, angel, man,
Beaſt, bird, fiſh, inſect, what no eye can ſee,
No glaſs can reach; from Infinite to thee,
From thee to nothing. POPE.

Even among mankind, which is a particular ſpecies, the ſcale of intellect is very extenſive; the degrees of intelligence extremely varied. What a difference, for inſtance, between the enlightened philoſopher of Europe, and the brutal ſavage of New Holland! Still, however, Nature obſerves, for the wiſeſt purpoſes, an uniform plan of gradation. Were all men philoſophers, the buſineſs of life could not be executed, and neither ſociety, nor even the ſpecies, could long exiſt. Induſtry, various degrees of knowledge, different diſpoſitions, and different talents, are great bonds of ſociety. Nature, indeed, has formed the human ſpecies, as it were, into caſts or rank. To ſome ſhe gives ſuperior genius and mental abilities; and, even of theſe, the views, the purſuits, and the taſtes, are wonderfully diverſified.

Not alike to every mortal eye
Is this great ſcene unveil'd. For while the claims
Of ſocial life to different labours urge
The active powers of man, with wiſeſt care
Hath Nature on the multitude of minds
Impreſs'd a various bias; and to each
Decreed its province in the common toil.
To ſome ſhe taught the fabric of the ſphere,
The changeful moon, the circuit of the ſtars,
The golden zones of heaven. To ſome ſhe gave
To ſearch the ſtory of eternal thought;
Of ſpace, and time; of fate's unbroken chain,
And will's quick movement. Others by the hand
She led o'er vales and mountains, to explore
What healing virtue dwells in every vein
Of herbs or trees. But ſome to nobler hopes
Were deſtin'd: ſome within a finer mould
She wrought, and temper'd with a purer flame.
To theſe the Sire Omnipotent unfolds,
In fuller aſpects and with fairer lights,
This picture of the world. Through every part
They trace the lofty ſketches of his hand:
In earth, or air, the meadow's flowery ſtore,

The moon's mild radiance, or the virgin's mien
Dreſs'd in attractive ſmiles, they ſee portray'd
(As far as mortal eyes the portrait ſcan)
Thoſe lineaments of beauty which delight
The Mind Supreme. They alſo feel their force,
Enamour'd : they partake the eternal joy.

AKENSIDE.

In the talents and qualities of quadrupeds of the ſame ſpecies, there are often remarkable differences. Theſe differences are conſpicuous in the various races of horſes, dogs, &c. Even among the ſame races, ſome are bold, ſprightly, and ſagacious: others are comparatively timid, phlegmatic, and dull.

Our knowledge of the chain of intellectual and corporeal beings is very imperfect; but what we do know affords the moſt exalted ideas of the variety and progreſſion which reign in the univerſe. An impenetrable cloud prevents our diſcerning the moſt beautiful and magnificent parts of this immenſe chain of beings. I ſhall endeavour, however, to point out a few of its more obvious links, which fall under our limited obſervation.

Man, even by his external qualities, ſtands at the head of this world. His relations are more extenſive than thoſe of any other animal: his form is more advantageous. His intellectual powers, when improved by ſociety, ſcience, and religion, exalt him ſo high, that, if no degrees of excellence exiſted among his own ſpecies, he would leave a great void in the chain of beings. Were we to conſider the characters, the manners, and the genius of different nations, of different provinces and towns, and even of the members of the ſame family, we ſhould imagine that the ſpecies of men were as various as the numbers of individuals. What gradations, as I have already obſerved, may be traced between the ſtupid ſavage and the enlightened philoſopher! Here the

diſtance is immenſe; but Nature has filled the whole with almoſt infinite ſhades of diſcrimination.

In deſcending the ſcale of animation, the next ſtep (which it is humiliating to remark) is very ſhort. Man, in his loweſt condition, is evidently linked, both in the form of his body and the capacity of his mind, to the large and ſmall orang-outangs. Theſe again, by another ſlight gradation, are connected to the apes, which, like the former, have no tails. From the apes to the baboons the interval is hardly perceptible. The true apes have no tails; and thoſe of the baboons are very ſhort. The monkeys, which form the next link, have long tails, and terminate this partial chain of imitative animals, which have ſuch a deteſtable reſemblance to our frame and manners.

When we examine the characters by which beings are diſtinguiſhed from each other, we perceive that ſome of them are more general, and include a greater variety than others. Hence are derived all our diſtributions into claſſes, orders, genera, and ſpecies. Between two claſſes, or two genera, however, Nature always exhibits intermediate productions, ſo cloſely allied, that it is extremely difficult to aſcertain to which of them they belong. The polypus, which multiplies by ſhoots, or by ſections, from its body, connects the animal to the vegetable kingdom. Thoſe worms, which lodge in tubes compoſed of ſand, ſeem to link the inſects to the ſhell and cruſtaceous animals. Shell animals and cruſtaceous inſects make, likewiſe, a near approach to each other. The muſcles and inſtruments of motion in both, are attached to external inſtead of internal bones. From reptiles, the degrees of perfection in animal life and powers proceed in a gradual but not imperceptible manner. The number of their organs of ſenſe, and the general conformation of their bodies, begin to have a greater analogy

to the ſtructure of thoſe animals which we are accuſtomed to conſider as belonging to the more perfect kinds. The ſnake, by its form, its movements, and its mode of living, is evidently connected with the eel and the water-ſerpent. Like reptiles, fiſhes, in general, are covered with ſcales, the colours and variety of which often enable us to diſtinguiſh one ſpecies from another. Their fins, from the medium in which they live, are analogous to the wings of birds. Their heads, like thoſe of reptiles, are immediately connected to their bodies, without the intervention of necks. The flying fiſhes, whoſe fins reſemble the wings of bats, form one link which unites the fiſhes to the feathered tribes. Aquatic birds, by a gentle gradation, ſucceed the flying fiſhes.

The tranſition from fiſhes to quadrupeds is almoſt imperceptible. The ſea-lion, the morſe, the whale, the crocodile, the turtle, the ſeal, have ſuch reſemblance both in their external and internal ſtructure, to terreſtrial quadrupeds, that ſome naturaliſts, in their methodical diſtributions, have ranked them under the ſame claſs of animals. The bat and the flying ſquirrel, which traverſe the air by means of membraneous inſtead of feathered wings, evidently connect quadrupeds with birds. The oſtrich, the caſſiowary, and the dodo, which rather run than fly, form another link between the quadruped and the bird.

Far as creation's ample range extends,
The ſcale of ſenſual, mental powers aſcends:
Mark how it mounts to man's imperial race,
From the green myriads in the peopled graſs;
What modes of ſight betwixt each wide extreme,
The mole's dim curtain, and the lynx's beam:
Of ſmell, the headlong lioneſs between,
And hound ſagacious on the tainted green:
Of hearing, from the life that fills the flood,
To that which warbles thro' the vernal wood!

The ſpider's touch, how exquiſitely fine!
Feels at each thread, and lives along the line:
In the nice bee, what ſenſe ſo ſubtly true
From poiſonous herbs extracts the healing dew,
How inſtinct varies in the groveling ſwine,
Compar'd, half reaſoning elephant, with thine!
'Twixt that, and Reaſon, what a nice barrier!
For ever ſeparate, yet for ever near!
Remembrance and Reflection how allied;
What thin partitions Senſe from Thought divide!
And middle natures, how they long to join,
Yet never paſs th' inſuperable line! POPE.

Among the variety of reflections to which this ſubject may lead us, one of the moſt ſtriking is, the conſideration of the arrogance and folly of man, in ſuppoſing himſelf to be the maſterpiece, and ſole end, of the whole creation. How low and contracted our views, to imagine that the fulneſs of the Divine Power and Wiſdom has been exhauſted upon a frail and impotent creature, who probably is the loweſt in the ſcale of rational beings! It is much more conſiſtent with the attributes of the great Creator to ſuppoſe, that we, who are next to the beaſts of the field, are far from making the neareſt approaches, without any intermediate order of beings, to the all-perfect Deity; that, as an uninterrupted chain of beings deſcends from man to brutes, from brutes to imperceptible inſects, it aſcends, likewiſe, by a beautiful gradation, from man to angel, to archangel, and to inconceivable orders of celeſtial ſpirits. How ſublime, how unutterable the idea of ſuch a gradation from man, to the moſt exalted of thoſe beings. Yet the dignity of theſe bears no more proportion to that of Him who dwells in unapproachable glory, than a gilded cloud, on which the evening ſun has impreſſed his beams, and enriched with beautiful ſtains, does to that great abyſs of light from which it derives its reflected beauty. He can ſtill create

beings, which ſhall as much ſurpaſs archangels of the higheſt order, as they ſurpaſs the moſt deſpicable inſect: for every nature, how exalted ſoever, muſt be infinite deſcents below an All-perfect Being.

Conſiderations of this kind open to man the bliſsful ſcenes of immortality. They teach him to look up to the Supreme Being with the moſt profound veneration, the moſt heartfelt gratitude, and the moſt devout aſpirations; and, by gradually improving his moral and intellectual powers, to riſe, at laſt, from his preſent ſtation in the univerſe, to the rank and felicity of celeſtial beings.

Say, why was man ſo eminently rais'd
Amid the vaſt creation; why impower'd
Thro' life and death to dart his watchful eye,
With thoughts beyond the limit of his frame;
But that the Omnipotent might ſend him forth,
In ſight of angels and immortal minds,
As on an ample theatre to join
In conteſt with his equals, who ſhall beſt
The taſk achieve, the courſe of noble toils,
By wiſdom and by mercy preordain'd?
Might ſend him forth the ſovran good to learn;
To chaſe each meaner purpoſe from his breaſt?
And thro' the miſts of paſſion and of ſenſe,
And thro' the pelting ſtorms of chance and pain,
To hold ſtraight on with conſtant heart and eye,
Still fix'd upon his everlaſting palm,
The approving ſmile of Heaven? - - - - - - - -
- - - - - - - - - - - - - - - For, from the birth
Of human kind, the ſovran Maker ſaid,
That not in humble, nor in brief delight,
Not in the fleeting echos of renown,
Power's purple robes, nor Pleaſure's flowery lap,
The ſoul ſhould find contentment; but, from theſe
Turning diſdainful to an equal good,
Thro' Nature's opening walks enlarge her aim,
Till every bound at length ſhould diſappear,
And infinite perfection fill the ſcene.

AKENSIDE.

These are thoughts that make man Man,
The wise illumine, aggrandize the great. - - - -
How great, in the wild whirl of Time's pursuits,
To stop, and pause, involv'd in high presage,
Through the long vista of a thousand years,
To stand contemplating our distant selves,
As in a magnifying mirror seen,
Enlarg'd, enobled, elevate, divine!
To prophesy our own futurities!
To gaze in thought on what all thought transcends!
To talk, with fellow-candidates, of joys
As far beyond conception as desert!
- - - - - - - - - - - - - - - - And, oh how great
To mingle interests, converse, amities,
With all the sons of Reason, scatter'd wide
Thro' habitable space, wherever born,
Howe'er endow'd! To live free citizens
Of universal nature! To lay hold
By more than feeble faith on the Supreme!
- - - - - To rise in science, as in bliss,
Initiate in the secrets of the skies!
To read creation; read its mighty plan!
The plan, and execution, to collate!
To see, before each glance of piercing thought,
All cloud, all shadow, blown remote; and leave
No mystery—but that of Love Divine! YOUNG.

LXIII. ON THE PRINCIPLE OF ASSOCIATION.

Far, far away, whoſe paſſions would immure,
In your own little hearts, the joys of life! - - - -
Know, for ſuperior ends, th' Almighty Power
Breathes o'er the foodful earth the breath of life,
And forms us manifold ; allots to each
His fair peculiar ; wiſdom, wit, and ſtrength ;
Wiſdom, and wit, and ſtrength, in ſweet accord,
To aid, to cheer, to counſel, to protect,
And twiſt the mighty bond. Thus feeble man,
With man united, is a nation ſtrong ;
Builds towery cities, ſatiates every want,
And makes the ſeas profound, and foreſts wild,
The gardens of his joys. DYER.

Nor think, in Nature's ſtate they blindly trod ;
The ſtate of Nature was the reign of God :
Self Love and Social at her birth began,
Union the bond of all things, and of man. POPE.

IN my former paper, I was engaged in the ſublime contemplation of the chain of beings in the univerſe ; in which an infinite variety of orders riſe,

From the mute ſhell-fiſh gaſping on the ſhore,
To men, to angels, to celeſtial minds. AKENSIDE.

I will now deſcend to our world, that comparatively minute part of the creation, and inquire into the principle of Aſſociation, by which the ſovereign Ruler of All has connected its innumerable inhabitants.

Some learned men have contended, that the natural ſtate of man is a ſtate of ſolitude and war. Others maintain, on the contrary, that the ſtate of man in ſociety is his natural ſtate ; and to this opinion I am led to accede, by an attentive obſervation, not of man alone, but of many inferior orders of animated nature.

Love, the firſt principle of the univerſe, and of all created beings, inſpires them with a natural inclination to unite. The birds that fly in the air, the animals that inhabit the earth, the fiſhes that rove in the water, all live in a kind of ſociety, which has laws proportionate to their nature and their wants. Beaſts, birds, and the inhabitants of the floods, aſſemble at the approach of danger. Bees aſſiſt each other in their exigencies; and a cock, in a farm-yard, will defend the hen of his fellow-cock. In a word, we have only to obſerve the face of Nature, in order to be convinced, that all animals have an idea of property; an idea, which is the neceſſary and abſolute conſequence of ſelf-love, of the deſire of preſervation, and of happineſs, which is natural to every being.

God, in the nature of each being, founds
Its proper bliſs, and ſets its proper bounds:
But as he fram'd a whole, the whole to bleſs,
On mutual wants, built mutual happineſs;
So from the firſt, eternal order ran,
And creature link'd to creature, man to man.
Whate'er of life all-quickening ether keeps,
Or breathes through air, or ſhoots beneath the deeps,
Or pours profuſe on earth, one nature feeds
The vital flame, and ſwells the genial ſeeds.
Not man alone, but all that roam the wood,
Or wing the ſky, or roll along the flood,
Each loves itſelf, but not itſelf alone,
Each ſex deſires alike, till two are one.
Nor ends the pleaſure with the fierce embrace;
They love themſelves, a third time, in their race.
Thus beaſt and bird their common charge attend,
The mothers nurſe it, and the ſires defend;
The young diſmiſs'd to wander earth or air,
There ſtops the inſtinct, and there ends the care;
The link diſſolves, each ſeeks a freſh embrace,
Another love ſucceeds, another race. POPE.

To return to man, let us consider him as in a state of perfect solitude. Will not the first question be, how came he there? Is not his very existence a proof of a previous society? But let us consider him again as perfectly unconnected, if it be possible, and without any regard to his origin: will he not constantly feel a natural impulse to propagate his species? Will he not incessantly seek a companion to satisfy that desire? And if he find one, is not this the commencement of society?

From this first state of society, a third human being is produced, who comes into the world destitute of the least ability to provide for his wants. At the very instant of his birth, he would perish, if Nature had not given his parents a love toward him, an inclination to nourish and support him. The Author of Nature has given milk to his mother for his sustenance, and strength to the father, to protect the mother and the child, and to provide them with subsistence. These are evident proofs of the natural and absolute necessity of society. But from the same father and mother are born several children; and these form a family. These children render to their parents, in their old age, what they received from them in their infancy: they protect them from injuries, and supply them with necessaries, when their strength decays, and they are no longer able to provide for themselves. Is this innate love, this attachment, or this instinct, which men and brutes have for the beings to which they have given existence, a circumstance of no consideration? Even the smallest of the feathered tribes have been known to pursue through the air those birds that have robbed them of their young, and to endeavour, at the hazard of their own lives, by incessant efforts and lamentations, to regain them. These very birds remain unconcerned, or hide themselves in their nests, when the bird of prey passes by with other

young ones of the ſame tribe in his talons. Objects, of this kind, are common in the country; and they prove, beyond diſpute, that property is a natural and inſeparable attribute of the exiſtence of every being. The mother, in this inſtance, ſeems to cry out, It is my child. And is man formed differently? Is he alone born without love, and without intereſt?

A longer care man's helpleſs kind demands;
The longer care contracts more laſting bands:
Reflection, reaſon, ſtill the ties improve,
At once extend the intereſt, and the love:
With choice we fix, with ſympathy we burn;
Each virtue in each paſſion takes its turn;
And ſtill new needs, new helps, new habits riſe,
That graft benevolence on charities.
Still as one brood, and as another roſe,
Theſe natural love maintain'd, habitual thoſe:
The laſt, ſcarce ripen'd into perfect man,
Saw helpleſs him from whom their life began:
Memory and forecaſt juſt returns engage,
That pointed back to youth, this on to age;
While pleaſure, gratitude, and hope combin'd,
Still ſpread the intereſt, and preſerve the kind. POPE.

The firſt natural condition of mankind is unqueſtionably the union of a male and female. Theſe produce a family, who, from neceſſity, or, in other words, from parental and filial affection, continue together, and aſſiſt each other in procuring food and ſhelter. This family, like moſt families in eſtabliſhed civil ſocieties, feel their own weakneſs, and their inability to ſupply their wants without more powerful reſources than their own feeble exertions. When this wandering and defenceleſs family accidentally meet with another family in the ſame condition, Nature teaches them to unite for mutual ſupport and protection. The aſſociation of two families may be conſidered as the firſt formation of a tribe or nation. When a number of tribes happen to

unite, they only become a larger or more numerous nation. A ſingle pair, it is true, if placed in a ſituation where plenty of food could be procured without much labour, might, in a ſucceſſion of ages, produce any indefinite number; and this is preciſely the ſituation, in which Moſes, in his hiſtory of the creation, has placed our firſt parents. In his account of the origin of ſociety, it may be obſerved, moreover, that the longevity of men, in the firſt ages of the world, was highly favorable to a ſpeedy population.

In countries thinly peopled with ſavages, it is extremely probable, that ſocieties are formed by the gradual union of families and tribes. The increaſe of power reſulting from mutual aſſiſtance, and a thouſand other comfortable circumſtances, ſoon contribute to cement more firmly the aſſociated members. Some of the arts of life, beſide that of hunting, are occaſionally diſcovered, either by accident, by the ingenuity of individuals, or even from an obſervation of the labours of the inferior animals in the creation.

See Man from Nature riſing ſlow to Art!
To copy Inſtinct then was Reaſon's part.
See then to Man the voice of Nature ſpake—
'Go, from the creatures thy inſtructions take:
Learn from the birds what food the thickets yield;
Learn from the beaſts the phyſic of the field;
Thy arts of building from the bee receive;
Learn of the mole to plow, the worm to weave;
Learn of the little nautilus to ſail,
Spread the thin oar, and catch the driving gale.
Here too all forms of ſocial union find,
And hence let Reaſon, late, inſtruct mankind:
Here ſubterraneous works and cities ſee;
There towns aërial on the waving tree.
Learn each ſmall people's genius, policies,
The ant's republic, and the realm of bees;

How thoſe in common all their wealth beſtow,
And anarchy without confuſion know;
And theſe for ever, though a monarch reign,
Their ſeparate cells and properties maintain.
Mark what unvaried laws preſerve each ſtate,
Laws wiſe as Nature, and as fix'd as Fate'. - - - -
Great Nature ſpake; obſervant Man obey'd;
Cities were built, ſocieties were made:
Here roſe one little ſtate; another near
Grew by like means, and join'd, through love or fear.

POPE.

The advances from the ſavage to the civilized ſtate of mankind thus appear to be gradual. This is a very conciſe view of the origin of ſociety, which has been adopted by moſt authors, both ancient and modern; for, not to enumerate the various fanciful theories of others, the origin of ſociety muſt, after all, be derived from its real and only ſource, Nature herſelf.

That the aſſociating principle is inſtinctive hardly requires a proof. An appeal to the feelings of any human being, and to the univerſal condition of mankind, is ſufficient. Theſe feelings, it may be ſaid, are acquired by education and habit. By theſe cauſes, it is true, our ſocial feelings are ſtrengthened and confirmed; but their origin is coeval with the exiſtence of the firſt human mind. Let any man attend to the eyes, the features, and the geſtures of a child upon the breaſt, when another child is preſented to it; both inſtantly, previous to the poſſibility of inſtruction or habit, exhibit the moſt evident expreſſions of joy. Their eyes ſparkle; their features and geſtures demonſtrate, in the moſt unequivocal manner, a mutual attachment, and a ſtrong deſire of approaching each other, not with a hoſtile intention, but with an ardent affection, which, in that pure and uncontaminated ſtate of our being, does honour to human nature. When further ad-

vanced, children who are ſtrangers to each other, although their ſocial appetite is equally ſtrong, diſcover a mutual ſhyneſs of approach. This ſhyneſs or modeſty, however, is ſoon conquered by the more powerful inſtinct of aſſociation. They daily mingle and ſport together. Their natural affections, which, at that period, are ſtrong, and unbiaſſed by thoſe ſelfiſh and vitious motives which too often conceal and thwart the intentions of Nature, create warm friendſhips that frequently continue during their lives, and produce the moſt beneficial and cordial effects. When we thus ſee with our eyes, that the aſſociating principle appears at a period much more early than many of our other inſtincts, who will attend to thoſe writers, who deny that man is naturally an aſſociating animal?

The advantages which we derive from aſſociation are innumerable. Man, from the comparatively great number of inſtincts with which his mind is endowed, neceſſarily poſſeſſes a portion of the reaſoning faculty highly ſuperior to that of any other animal. He alone enjoys the power of expreſſing and communicating his ideas by articulate and artificial language. This ineſtimable prerogative is, perhaps, one of the greateſt ſecondary bonds of ſociety, and the greateſt ſource of improvement to the human intellect. Without artificial language, although Nature has beſtowed on every animal a mode of expreſſing its wants and deſires, its pleaſures and pains, what an humiliating figure would the human ſpecies exhibit, even upon the ſuppoſition that they did aſſociate! But when aſſociation and language are conjoined, the human intellect, in the progreſs of time, arrives at a high degree of perfection. Society gives riſe to virtue, honour, government, ſubordination, arts, ſcience, order, happineſs. All the individuals of a community conduct themſelves upon a regulated ſyſtem.

First gathering men their natural powers combin'd,
And form'd a Public; to the general good
Submitting, aiming, and conducting all. - - -
Hence every form of cultivated life
In order set, protected, and inspir'd,
Into perfection wrought. Uniting all
Society grew numerous, high, polite,
And happy. Nurse of art! the city rear'd,
In beauteous pride, her tower-encircl'd head. - - -
Then Commerce brought into the public walk
The busy merchant. - - - - - - -
Then too the pillar'd dome, magnific, heav'd
Her ample roof; and Luxury within
Pour'd out her glittering stores; the canvas smooth,
With glowing life protuberant, to the view
Embodied rose; the statue seem'd to breathe,
And soften into flesh, beneath the touch
Of forming Art. - - - - - - - - -
The gift of *Social Labour* these; whate'er
Exalts, embellishes, and renders life
Delightful: - - - - - - - - -
He, the kind source of every gentle art,
And all the soft civility of life!
- - - - - - Pensive Winter, cheer'd by him,
Sits at the social fire, and happy hears
Th' excluded tempest idly rave along;
His harden'd fingers deck the gaudy Spring;
Without him Summer were an arid waste;
Nor to th' Autumnal months could e'er transmit
Those full, mature, immeasurable stores,
That beauteous wave around. THOMSON.

LXIV. ON THE FEATHERED CREATION.

Videmus
Frondiferasque novis avibus canere undique sylvas.
LUCRETIUS.

Innumerous songsters, in the freshening shade
Of new-sprung leaves, their modulations mix
Mellifluous. THOMSON.

THE vocal groves, and the woodland quiristers, have been favourite themes with the bard, whom the love of Nature inspires, and whose breast is formed by virtue to a true relish for her charms.

In Milton, the angel Raphael, describing the creation of the world to Adam, forgets not the feathered tribes:

Mean while the tepid caves, and fens and shores
Their brood as numerous hatch, from th' egg that soon
Bursting with kindly rupture forth disclos'd
Their callow young, but feather'd soon and fledg'd
They summ'd their pens, and soaring th' air sublime
With clang despis'd the ground, under a cloud
In prospect: there the eagle and the stork
On cliffs and cedar tops their eyries build:
Part loosely wing the region, part more wise,
In common, rang'd in figure wedge their way,
Intelligent of seasons, and set forth
Their aery caravan high over seas
Flying, and over lands with mutual wing
Easing their flight: so steers the prudent crane
Her annual voyage, born on winds; the air
Floats, as they pass, fann'd with unnumber'd plumes:
From branch to branch the smaller birds with song
Solaced the woods, and spread their painted wings
Till ev'n, nor then the solemn nightingale
Ceas'd warbling, but all night tun'd her soft lays:

Others on ſilver lakes and rivers bath'd
Their downy breaſt; the ſwan with arched neck
Between her white wings mantling proudly, rows
Her ſtate with oary feet; yet oft they quit
The dank, and riſing on ſtiff pennons, tower
The mid aërial ſky. Others on ground
Walk'd firm; the creſted cock whoſe clarion ſounds
The ſilent hours, and th' other whoſe gay train
Adorns him, coloured with the florid hue
Of rainbows and ſtarry eyes.

Nor can that delightful ſeries of pictures, ſo truly expreſſive of the general ſpirit that pervades the Spring, which Thomſon has formed on the variety of circumſtances attending "the paſſion of the groves", eſcape the notice and attention of the moſt negligent eye. With him, we ſee the gay troops begin to plume the painted wing, and try again the long-forgotten ſtrain. The woods reſound with laviſh harmony. Attentive to the voice of love, we behold the gloſſy kind pour forth their little ſouls in courtſhip to their mates. Having formed connubial leagues, they retire to their reſpective haunts, and build their neſts with inimitable ſkill. The parental cares now engage their attention; and with what courage, and with what art, do they employ the varied ſtratagem, to divert from their tender progeny the rude foot that would moleſt them! How ſweetly too does the poet lament the barbarous art, that deprives the ſoft tribes of liberty and boundleſs air! How pathetically bemoan the miſery of the nightingale, when, returning to her young with loaded bill, ſhe finds a vacant neſt, robbed by the hard hand of ſome unrelenting clown! What a picture does he exhibit, when the feathered youth firſt attempt to fly; when, the laſt glad office done, parental love, grown needleſs, diſſolves at once! Nor does he forget the royal eagle, in his towering ſeat;

nor the cawing rook in his airy city; nor the various policy of the mixed domeſtic kind [a].

What is this Mighty Breath, ye ſages ſay,
That, in a powerful language, felt, not heard,
Inſtructs the fowls of heaven; and thro' their breaſt
Theſe arts of love diffuſes? What but God!
Inſpiring God! who, boundleſs Spirit all,
And unremitting Energy, pervades,
Adjuſts, ſuſtains, and agitates the whole.
He ceaſeleſs works *alone*; and yet *alone*
Seems not to work; with ſuch perfection fram'd
Is this complex ſtupendous ſcheme of things!
But, tho' conceal'd to every purer eye
Th' informing Author in his works appears:
Chief, lovely Spring, in thee, and thy ſoft ſcenes,
The ſmiling God is ſeen; while water, earth,
And air, atteſt his bounty; which exalts
The brute creation to this finer thought,
And annual melts their undeſigning hearts
Profuſely thus in tenderneſs and joy [b].

Birds may certainly be ranked among the moſt beautiful creatures in the world. The ſtructure and conformation of their bodies, even of their minuteſt parts, is ſo regular and perfect, as to exhibit the moſt convincing proofs of the wiſdom and providence of God. The mechaniſm that produces the various motions of the winged tribe, is wonderful. The anatomical deſcriptions, contained in the treatiſes on ornithology, or the natural hiſtory of birds, are extremely curious and intereſting. But, not to enter into a detail, that would be too extenſive for the limits of this paper, I ſhall be content, on this head, to quote the obſervation of M. Vicq d'Azyr, an ingenious French naturaliſt: "It is particularly worthy of obſervation, that in comparing the muſcles and bones of birds with thoſe of the human ſpecies, the analogies are found to be much greater,

[a] Spring, line 569 to 785. [b] Ib. line 846, &c.

and more ſtriking, than could have been expected, conſidering the little reſemblance there is between the external forms of theſe two claſſes. This evinces the beautiful uniformity that reigns in the great ſcheme of nature, and that in orders of Being ſo different. It is alſo a remarkable proof of final cauſes, when we conſider that the diverſities of this otherwiſe uniform plan, are exactly ſuited to the nature, ſtructure, and motions, which characterize each claſs [a]".

The bodies of birds are formed, in every part, with ſuch ſkill and harmony, as to be perfectly conformable to their manner of living, and to their reſpective neceſſities. The ſtork and heron, which are obliged to ſeek their food chiefly in the marſhes, have long bills, and alſo very long legs, that they may run into the water without wetting their bodies, and yet reach their prey at a diſtance. The bills of woodcocks, ſnipes, and other birds, which hunt for worms in mooriſh grounds, and which (as Mr. Willoughby obſerves) live alſo on the fat unctuous humours they ſuck out of the earth, are likewiſe very long; as are alſo the bills of curlews, and other ſeafowl, that hunt for their food on the ſand of the ſeaſhore. The eagle and vulture, which are rapacious birds, have large wings, ſtrong talons, and ſharp-edged beaks. The hooked form of the bills of parrots is of great ſervice to them, in climbing, and catching hold of boughs. The upper bill of this bird is filled with rows of croſs bars; and the under bill, which is much ſhorter, ſhuts within the upper, and draws againſt the roof of the mouth; by which means a kind of maſtication is effected, before the meat paſſes into the craw. Ducks, geeſe, and many others, have long broad bills, to enable them to grope for their food in waters and mud.

[a] Hiſt. de l'Acad. des Sciences à Paris, 1773.

On the contrary, a thick, ſhort, and ſharp-edged bill is as uſeful to other birds, who have occaſion to huſk and flay the grain they ſwallow. The woodpecker's bill is ſtrong, and ſharp enough to dig holes, and build in the heart of the hardeſt timber. The loxia, or croſsbill, whoſe bill is thick and ſtrong, with the tips croſſing each other, breaks open fir-cones, apples, and other fruit, to come at the kernels, with ſuch eaſe, as if the croſſing of the bill were for this ſervice. The ſea-pies have a long, ſharp, narrow bill, compreſſed ſidewiſe, and in every reſpect ſo well adapted to the raiſing of limpets from the rocks, that Providence ſeems to have framed it on purpoſe to enable it to procure that fiſh, which is its chief, if not its only food [a]. The bills of ſwallows are ſlender and ſharp-pointed: with a very wide mouth, to enable them the more conveniently to catch inſects which are their food, in their ſwifteſt flight.—Moreover, in the bills of all birds, there is an admirable proviſion for the judging of their food, by certain nerves calculated peculiarly for that purpoſe; ſmall, and leſs numerous, in ſuch as have the aſſiſtance of another ſenſe, the eye, but large, more numerous, and thickly branched about to the very end of the bill, in ſuch as hunt for their food, out of ſight, in water, mud, or under ground. —Theſe obſervations on the ſtructure of birds, might be extended to many pages: I ſhall, therefore, only obſerve further, with reſpect to their tail, that Willoughby, Ray, and many others, imagine its principal uſe to be to ſteer, and to turn the body in the air, as a rudder. But Borelli has demonſtrated, that this is the leaſt uſe of it, and that it is chiefly to

[a] The eaſe with which this bird, by means of its bill, can raiſe the limpet, is the more wonderful, as this ſhellfiſh adheres ſo firmly to the rock, as to be ſeparated with great difficulty by a knife. To ſome that adhered horizontally to the rock, Mr. Reaumur cauſed a line and weight to be affixed: the leaſt weight capable of moving it, he found to be thirty pounds, and even this it reſiſted for ſome time.

aſſiſt the bird in aſcending and deſcending in the air, and to obviate the vacillations of the body and wings: for, with reſpect to the turning to either ſide, it is performed by the wings, and inclination of the body, and but very little by the aſſiſtance of the tail [a].

The inſtinct and induſtry of birds are in nothing more apparent than in the building of their neſts. How regular and admirable are theſe little edifices, formed of ſuch different materials, collected and arranged with ſuch judgement and labour, and conſtructed with ſuch elegance and neatneſs, without any other tools than a beak and two feet!

It wins my admiration,
To view the ſtructure of that little work,
A bird's neſt. Mark it well within, without.
No tool had he that wrought, no knife to cut,
No nail to fix, no bodkin to inſert,
No glue to join: his little beak was all,
And yet how neatly finiſhed! What nice hand
With every implement and means of art,
And twenty years apprenticeſhip to boot,
Cou'd make me ſuch another? Fondly then
We boaſt of excellence, whoſe nobleſt ſkill
Inſtinctive genius foils. VILLAGE CURATE.

Inſtinctive ingenuity is apparent in all their neſts. But the extraordinary ſubtilty of the long-tailed titmouſe deſerves particular admiration. With great art, ſhe builds her neſt with moſs, hair, and the webs of ſpiders, caſt out from them when they take their flight [b], with which the materials are ſtrongly tied together. Having neatly built, and covered her neſt with

[a] Borelli de Motu Animalium.

[b] Spiders, which cannot fly, have an admirable faculty to convey themſelves with ſpeed and ſafety, by the help of their webs, or ſome other artifice, to make their bodies lighter than the air. I have with pleaſure often ſeen them dart out their webs, and ſail away by the help thereof. *Derham's Phyſico-Theology, book* viii, *ch.* 4.

these materials, she thatches it on the top with the *muscus aboreus ramosus*, or such like broad whitish moss, to keep out rain, and to deceive the eye of any one that might pass near it. The interior part she lines with a great number of small feathers; with so many, that Mr. Derham says he could not but admire how so small a room could hold them; especially, that they could be laid so close and handsomely together, to afford sufficient room for a bird with so long a tail, and so numerous an issue as this bird commonly hath [a].

Mr. Pennant, in his account of the *taylor bird*, exhibits another instance of the wonderful effect of animal instinct: "Had Providence (says he) left the feathered tribe unendued with any particular instinct, the birds of the *torrid zone* would have built their nests in the same unguarded manner as those of Europe; but *there* the lesser species having a certain prescience of the dangers that surround them, and of their own weakness, suspend their nests at the extreme branches of the trees; conscious of inhabiting a clime replete with enemies to them and their young—snakes that twine up the bodies of the trees, and apes that are perpetually in search of prey; but, heaven-instructive, they elude the gliding of the one, and the activity of the other. Some form their pensile nest in the shape of a purse, deep and open at top; others with a hole in the side; and others, still more cautious, with an entrance at the very bottom, forming their lodge near the summit.—But the little species here described seem to have greater diffidence than any of the others. It will not trust its nest even to the extremity of the slender twig, but makes one more advance to safety, by fixing it to the leaf itself. It picks up a *dead* leaf, and, surprising to relate, *sews* it to the side of a living one, its slender

[a] Physico-Theology, book iv, ch. 13.

bill being its needle, and its thread ſome fine fibres; the lining, feathers, goſſamer, and down[a]".

The unerring inſtinct which guides every ſpecies of the feathered race, in contriving the moſt proper habitation for the hatching of their young, inſtructs them alſo to repair to the ſituation the moſt ſuitable for them, with reſpect to their food, their pleaſure, and their ſafety. Hence, the choice of each ſpecies is invariably the ſame. Some repair to the rude thicket; ſome to the cleft or hollow tree. Some weave their humble neſts in the graſſy dale, or roughening waſte. Others delight in ſhaggy banks, in woodland ſolitudes, and unfrequented glooms. Some build in the towering tree, or inacceſſible rock; and others prefer the vicinity of man, and take ſhelter in his chimnies, or in his hoſpitable caves.

But who the various nations can declare
That plough with buſy wing the peopled air?
Theſe cleave the crumbling bark for inſect food:
Thoſe dip the crooked beak in kindred blood;
Some haunt the ruſhy moor, the lonely woods;
Some bathe their ſilver plumage in the floods;
Some fly to man, his houſhold gods implore,
And gather round his hoſpitable door,
Wait the known call, and find protection there
From all the leſſer tyrants of the air.
The tawny eagle ſeats his callow brood
High on the cliff, and feaſts his young with blood.
On Snowden's rocks, or Orkney's wide domain,
Whoſe beetling cliffs o'erhang the weſtern main,

[a] Mr. Pennant has given a picture of this extraordinary piece of architecture: the *live* leaf, which ſerves for its baſis, being that of the mango-tree, with the neſt affixed to it, and the birds projecting their little heads above the entrance of their pendent habitations. He informs us alſo, that one of theſe curious neſts is preſerved in the Britiſh Muſeum. The colour of theſe ingenious *flying taylors* is a light yellow; its eggs are white; its length is three inches; its weight only three ſixteenths of an ounce; ſo that the materials of the neſt, and its own ſize, are not likely to draw down a habitation that depends on ſo ſlight a tenure. *Indian Zoology, part* i.

The royal bird his lonely kingdom forms
Amid the gathering clouds and ſullen ſtorms:
Through the wide waſte of air he darts his ſight,
And holds his ſounding pinions pois'd for flight;
With cruel eye premeditates the war,
And marks his deſtined victim from afar[a]:
Deſcending in a whirlwind to the ground,
His pinions like the ruſh of waters ſound;
The faireſt of the fold he bears away,
And to his neſt compels the ſtruggling prey.

BARBAULD.

Although the ſparrows, in general, conſtruct their neſts under the tiles of houſes, or in holes in the walls, ſome build them on the tops of trees. This difference of ſituation affords them an opportunity of exhibiting a ſingular inſtance of inſtinctive ſagacity. In the neſts built on trees they form an artificial roof, which covers the neſt, and prevents the entrance of rain; forming, at the ſame time, an opening under it: on the contrary, when they build under cover, they abſtain from this work of ſupererogation. Inſtinct (ſays the celebrated Buffon) is manifeſted in this caſe, in a manner nearly analogous to reaſon; as it ſuppoſes, at leaſt, the comparing together of two ideas. In this little race, there is a diverſity of manners, and a more varied and perfected inſtinct than in moſt other birds. This improvement he aſcribes to their frequenting human ſociety. They are in part domeſticated; but without being ſubjected to it, or loſing their independence. From this ſociety they draw whatever ſuits their convenience, and in it they acquire that ſubtilty, circumſpection, and improvement of the inſtinctive faculty, which is exhibited in the great va-

[a] Doth the eagle mount up at thy command, and make her neſt on high? She dwelleth and abideth on the rock, upon the crag of the rock, and the ſtrong place: thence ſhe ſeeketh the prey, and her eyes behold afar off. *Job.* xxxix, 27—29.

riety of their habits, relative to different ſituations, ſeaſons, and other circumſtances [a].

I might here extend my obſervations to the *incubation* and *migration* of birds: but theſe ſhall be noticed in ſome future papers [b]. I ſhall only add, at preſent, that from the conſideration of the providential care ſo evidently manifeſted in the preſervation of the aerial tribes, the divine Teacher of our holy religion has drawn an argument to prevent our ſinking into anxiety and deſpondence, and to induce us to rely with filial confidence and piety in the goodneſs of our heavenly Parent: "Behold the fowls of the air: for they ſow not, neither do they reap, nor gather into barns; yet our heavenly Father feedeth them. Are ye not much better than they"?

Behold, and look away your low deſpair!
See the light tenants of the barren air:
To them, nor ſtores, nor granaries belong;
Nought, but the woodland, and the pleaſing ſong;
Yet, your kind heavenly Father bends his eye
On the leaſt wing that flits along the ſky.
To him they ſing when ſpring renews the plain,
To him they cry in winter's pinching reign;
Nor is their muſic, or their plaint in vain:
He hears the gay, and the diſtreſsful call,
And with unſparing bounty fills them all.
If, ceaſeleſs, then the fowls of heaven he feeds,
If o'er the fields ſuch lucid robes he ſpreads;
Will he not care for you, ye faithleſs, ſay?
Is he unwiſe? Or, are ye leſs than they? THOMSON.

[a] Hiſtoire Naturelle des Oiſeaux, tome iii.

[b] The two ſucceeding Numbers are on the ſubject of *migration*; in No LXVIII, On the Inſtinct of Brutes, are ſome obſervations on the *uniformity* of the neſts of the different ſpecies of birds; and in No. LXX, On the Habitations of animals, are ſome further obſervations on the *nidification* and *incubation* of ſeveral birds.

LXV. ON THE MIGRATION OF BIRDS.

Yea, the ſtork in the heaven knoweth her appointed times; and the turtle, and the crane, and the ſwallow, obſerve the time of their coming. JEREMIAH.

Who bid the ſtork, Columbus-like, explore
Heavens not his own, and worlds unknown before?
Who calls the council, ſtates the certain day?
Who forms the phalanx, and who points the way?
POPE.

THE migration of birds has been juſtly conſidered as one of the moſt wonderful inſtincts of Nature. Milton, in the paſſage I quoted in my preceding paper, ſtyles the feathered race, thus divinely taught, "intelligent of ſeaſons"; and the venerable prophet above adduces this inſtinctive and invariable obſervation of their appointed times, as a circumſtance of reproach to the choſen people of God, who, although taught by reaſon and religion, "knew not the judgement of the Lord".

The appearance and diſappearance of the birds of ſeaſon, particularly in the Hebrides, or Weſtern Iſlands of Scotland, has not been diſregarded by our own poets. Thus Mallet ſpeaks of the birds that annually tranſmigrate to St. Kilda, the moſt remote and unfrequented of all thoſe iſlands:

But, high above, the ſeaſon full exerts
Its vernant force in yonder peopled rocks,
To whoſe wild ſolitude, from worlds unknown,
The birds of paſſage tranſmigrating come,
Unnumber'd colonies of foreign wing,
At Nature's ſummon, their aërial ſtate
Annual to found: and in bold voyage ſteer,
O'er this wide ocean, through yon pathleſs ſky,

One certain flight to one appointed ſhore:
By Heaven's directive ſpirit, here to raiſe
Their temporary realm; and form ſecure,
Where food awaits them copious from the wave,
And ſhelter from the rock, their nuptial leagues:
Each tribe apart, and all on taſks of love,
To hatch the pregnant egg, to rear and guard
Their helpleſs infants, piouſly intent.

Their appearance in the ſame iſlands is thus noticed by Thomſon:

Where the northern ocean, in vaſt whirls,
Boils round the naked melancholy iſles
Of furtheſt Thulé, and th' Atlantic ſurge
Pours in among the ſtormy Hebrides;
Who can recount what tranſmigrations there
Are annual made? What nations come and go?
And how the living clouds on clouds ariſe?
Infinite wings! till all the plume-dark air,
And rude reſounding ſhore, are one wild cry.

And their diſappearance from the ſame ſcenes is thus deſcribed by Mrs. Barbauld:

When winter bites upon the naked plain,
Nor food nor ſhelter in the groves remain,
By inſtinct led, a firm united band,
As marſhall'd by ſome ſkilful general's hand,
The congregated nations wing their way
In duſky columns o'er the trackleſs ſea;
In clouds unnumber'd annual hover o'er
The craggy Baſs, or Kilda's utmoſt ſhore:
Thence ſpread their ſails to meet the ſouthern wind,
And leave the gathering tempeſt far behind,
Purſue the circling ſun's indulgent ray,
Courſe the ſwift ſeaſons, and o'ertake the day.

The migration of birds, which is common to the quail, the ſtork, the crane, the fieldfare, the woodcock, the cuckow, the martin, the ſwallow, and various others, is, indeed, a very curious article in

natural hiſtory, and furniſhes a very ſtriking inſtance of a powerful inſtinct impreſſed by the Creator. Dr. Derham obſerves two circumſtances remarkable in this migration: the firſt, that theſe untaught, unthinking creatures, ſhould know the proper times for their paſſage, when to come, and when to go; as alſo, that ſome ſhould come when others go. No doubt, the temperature of the air as to heat and cold, and their natural propenſity to breed their young, are the great incentives to theſe creatures to change their habitations. But why ſhould they at all change their habitations? And why is not ſome certain place to be found, in all the terraqueous globe, that, all the year round, can afford them convenient food and habitation?—The ſecond remarkable circumſtance is, that they ſhould know which way to ſteer their courſe, and whither to go. What inſtinct is it that can induce a poor fooliſh bird to venture over vaſt tracts of land and ſea? If it be ſaid, that by their high aſcents into the air, they can ſee acroſs the ſeas; yet what ſhall inſtruct or perſuade them, that another land is more proper for their purpoſe than this? That Great Britain, for inſtance, ſhould afford them better accommodation than Egypt, the Canaries, Spain, or any of the other intermediate countries [a]?

The birds of paſſage, moreover, are all peculiarly accommodated, by the ſtructure of their parts, for long flights; and it is remarked, that, in their migrations, they obſerve a wonderful order and polity: they fly in troops, and ſteer their courſe, without the aid of a compaſs, to vaſt unknown regions. The flight of the wild geeſe, in a wedge-like figure, has been often obſerved; to which it is added, by the natural hiſtorian of Norway, that the three foremoſt, who are the ſooneſt tired, retreat behind, and are relieved by others, who are again ſucceeded by the

[a] Phyſico-Theology, book vii. chap. 3.

reſt in order [a]. But this circumſtance has been obſerved, many ages before, by Pliny, who deſcribes certain birds of paſſage flying in the form of a wedge, and ſpreading wider and wider; thoſe behind reſting upon thoſe before, till the leaders, being tired, are, in their turn, received into the rear [b]. "Wild ducks and cranes (ſays abbé de la Pluche) fly at the approach of winter, in queſt of more favorable climates. They all aſſemble, at a certain day, like ſwallows and quails. They decamp at the ſame time, and it is very agreeable to obſerve their flight. They generally range themſelves in a long column like an I, or in two lines united in a point like a V reverſed". And thus, as Milton ſays,

rang'd in figure wedge the way.

"The duck or quail that forms the point (adds the abbé) cuts the air, and facilitates a paſſage to thoſe that follow: but he is charged with this commiſſion only for a certain time, at the concluſion of which he wheels into the rear, and another takes his poſt [c]". And thus again, as Milton obſerves,

with mutual wing
Eaſing their flight.

It has been obſerved of the ſtorks, that, for about the ſpace of a fortnight before they paſs from one country to another, they conſtantly reſort together, from all the circumjacent parts, to a certain plain, and there forming themſelves once every day into a *dou-wanne* (according to the phraſe of the people) are ſaid to determine the exact time of their departure, and the places of their future abode [d].

[a] Bp. Pontoppidan.

[b] A tergo ſenſim dilatante ſe cuneo porrigitur agmen, largèque impellenti præ betu auræ. Colla imponunt præcendentibus: feſſos duces ad terga recipiunt. Nat. Hiſt. l. x. ſect. 32.

[c] Spectacle de la Nature, dial. ix.

[d] Shaw's Travels, p. 428. fol.

Where the Rhine loſes its majeſtic force
In Belgian plains, won from the raging deep,
By diligence amazing, and the ſtrong
Unconquerable hand of Liberty,
The ſtork-aſſembly meets; for many a day,
Conſulting, deep, and various, ere they take
Their arduous voyage thro' the liquid ſky.
And now their route deſign'd, their leaders choſe,
Their tribes adjuſted, clean'd their vigorous wings;
And many a circle, many a ſhort eſſay,
Wheel'd round and round, in congregation full
The figur'd flight aſcends; and, riding high
The aërial billows, mixes with the clouds.

THOMSON.

Mr. Biberg, an ingenious naturaliſt of Sweden, has obſerved, that "the ſtarling, finding, after the middle of ſummer, that worms are leſs plentiful in that country, goes annually into Scania, Germany, and Denmark. The female chaffinches, every winter, about Michaelmas, go in flocks to Holland; but as the males ſtay in Sweden, the females come back next ſpring, except ſuch as chooſe to breed no more. In the ſame manner, the female Carolina yellow-hammer, in the month of September, while the rice on which ſhe feeds is laid up in granaries, goes toward the ſouth, and returns in the ſpring to ſeek her mate. Our aquatic birds (continues he) are forced by neceſſity to fly toward the ſouth every autumn, before the water is frozen. Thus we know, that the lakes of Poland and Lithuania are filled with ſwans and geeſe every autumn, at which time they go in great flocks, along many rivers, as far as the Euxine Sea. But in the beginning of ſpring, as ſoon as the heat of the ſun moleſts them, they return back, and go again to the northern ponds and lakes, in order to lay their eggs. For there, and eſpecially in Lapland, there is a vaſt abundance of gnats, which afford them excellent nouriſhment,

as all of this kind live in the water before they get their wings"—Mr. Biberg proceeds to enumerate many other birds that migrate to different regions; and he then adds: "By these migrations, birds become useful to many different countries, and are distributed over almost all the globe; and I cannot here forbear expressing my admiration, that all of them exactly observe the times of coming and going, and that they never mistake their way [a]".

The principal food of the birds of passage, while in Great Britain, is the fruit of the white thorn, or haws, which hang on our hedges in winter in prodigious plenty; but where they breed, and seem to be most at ease, as in Sweden, &c. there are no haws; nor indeed in many of the countries through which they journey on their way: so that it is evident they change their food in their passage.

The manner in which the birds of passage journey to their southern abodes is supposed to vary, according to the different structure of their bodies, and their power of supporting themselves in the air. The birds with short wings, such as the redstart, blackcap, &c. though they are incapable of such long flights as the swallow, or of flying with such celerity, yet may pass to less distant places, and by slower movements. Swallows and cuckows may perform their passage in a very short time; but there is for them no necessity for speed, since every day's passage affords them an increase of warmth, and a continuance of food.

Swallows are often observed, in innumerable flocks, on churches, rocks, and trees, previous to their departure hence; and Mr. Collinson proves their return here, perhaps in equal numbers, by two curious relations of undoubted credit; the one communicated to him by Mr. Wright, the master of a

[a] Biberg On the Economy of Nature, in Stillingfleet's Miscellaneous Tracts.

ſhip, and the other by admiral ſir Charles Wager. —"Returning home (ſays ſir Charles) in the ſpring of the year, as I came into ſoundings in our channel, a great flock of ſwallows came and ſettled on my rigging; every rope was covered; they hung on one another like a ſwarm of bees; the decks and carving were filled with them. They ſeemed almoſt famiſhed and ſpent, and were only feathers and bones; but, being recruited with a night's reſt, they took their flight in the morning".—This apparent fatigue proves, that they muſt have had a long journey, conſidering the amazing ſwiftneſs of theſe birds; ſo that, in all probability, they had croſſed the Atlantic ocean, and were returning from the ſhores of Senegal, or other parts of Africa.—But the ſtate of the ſwallow-tribes, when they are no longer ſeen in our northern regions, has given riſe to a curious controverted queſtion among naturaliſts, of which I ſhall treat in my next paper. In the mean time, my readers, I am perſuaded, will be pleaſed with the following beautiful poetical welcome to theſe birds, on their re-appearance in the Spring, by the contemporary and friend of Shenſtone and Collins:

At length the winter's ſurly blaſts are o'er;
  Array'd in ſmiles the lovely ſpring returns:
Health to the breeze unbars the ſcreaming door,
  And every breaſt with heat celeſtial burns.

And ſee, my Delia, ſee o'er yonder ſtream,
  Where on the ſunny bank the lambkins play;
Alike attracted to th' enliv'ning gleam,
  The ſtranger-ſwallows take their wonted way.

Welcome, ye gentle tribe, your ſports purſue,
  Welcome again to Delia, and to me:
Your peaceful councils on my roof renew,
  And plan your ſettlements from danger free.

No tempeſt on my ſhed its fury pours,
  My frugal hearth no noxious blaſt ſupplies;
Go, wand'rers, go, repair your ſooty bow'rs,
  Think, on no hoſtile roof my chimnies riſe.

Again I'll liſten to your grave debates,
  I'll think I hear your various maxims told,
Your numbers, leaders, policies, and ſtates,
  Your limits ſettled, and your tribes enroll'd.

I'll think I hear you tell of diſtant lands,
  What inſect-nations riſe from Egypt's mud,
What painted ſwarms ſubſiſt on Libya's ſands,
  What mild Euphrates yields, and Ganges' flood.

Thrice happy race! whom Nature's call invites
  To travel o'er her realms with active wing,
To taſte her choiceſt ſtores, her beſt delights,
  The ſummer's radiance, and the ſweets of ſpring:

While we are doom'd to bear the reſtleſs change
  Of ſhifting ſeaſons, vapours dank, or dry,
Forbid, like you, to milder climes to range,
  When wintry clouds deform the troubled ſky.

But know the period to your joys aſſign'd!
  Know ruin hovers o'er this earthly ball;
Certain as fate, and ſudden as the wind,
  Its ſecret adamantine props ſhall fall.

Yet when your ſhort-liv'd ſummers ſhine no more,
  My patient mind, ſworn foe to vice's way,
Suſtain'd on lighter wings than yours, ſhall ſoar
  To fairer realms beneath a brighter ray:

To plain etherial, and Elyſian bowers,
  Where wintry ſtorms no rude acceſs obtain,
Where blaſts no light'ning, and no thunder low'rs,
  But ſpring and joy unchang'd for ever reign.

JAGO.

LXVI. FURTHER REFLECTIONS ON THE MIGRATION OF BIRDS.

Where do the cranes, or winding ſwallows, go,
Fearful of gathering winds and falling ſnow?
If into rocks, or hollow trees, they creep,
In temporary death confined to ſleep;
Or, conſcious of the coming evil, fly
To milder regions and a ſouthern ſky? PRIOR.

I INTIMATED, in my former paper, that the ſtate of the ſwallow-tribes, when they are no longer ſeen in our regions, has given riſe to a controverted queſtion in natural hiſtory. The poets, as well as the philoſophers, ſeem to be divided on the ſubject. Thus Anacreon, as paraphraſed by Cowley, addreſſes the ſwallow:

In thy undiſcover'd neſt
Thou doſt all the winter reſt,
And dreameſt o'er thy ſummer joys,
Free from the ſtormy ſeaſon's noiſe.

And Thomſon, in noticing their diſappearance in autumn, ſpeaks with the ſame uncertainty on the ſubject, as does the poet in my motto:

When Autumn ſcatters his departing gleams,
Warn'd of approaching Winter, gather'd, play
The ſwallow-people; and toſs'd wide around,
O'er the calm ſky, in convolution ſwift,
The feather'd eddy floats: rejoicing once,
Ere to their wintry ſlumbers they retire;
In cluſters clung, beneath the mouldring bank,
And where, unpierc'd by froſt, the cavern ſweats.
Or rather into warmer climes convey'd,
With other kindred birds of ſeaſon, there
They twitter cheerful, till the vernal months
Invite them welcome back: for, thronging, now
Innumerous wings are in commotion all.

Naturalists, as I have before observed, are likewise much divided in their opinion concerning the periodical appearance and disappearance of swallows. Some assert, that they remove from climate to climate, at those particular seasons when winged insects, their natural food, fail in one country, and are plentiful in another, where they likewise find a temperature of air better suited to their constitution. In support of this opinion we have the testimony of sir Charles Wager, mentioned in my preceding paper, and of M. Adanson, who, in the account of his voyage, informs us, that, about fifty leagues from the coast of Senegal, four swallows settled upon the ship, on the sixth day of October; that these birds were taken; and that he knew them to be the true swallow of Europe, which he conjectures were then returning to the coast of Africa. But Mr. Daines Barrington, in a curious essay on this subject[a], has adduced many arguments and facts, to prove, that no birds, however strong and swift in their flight, can possibly fly over such large tracks of the ocean as has been commonly supposed. He is of opinion, therefore, that the swallows mentioned by M. Adanson, instead of being on their passage from Europe, were only fluttering from the Cape de Verde Islands to the continent of Africa; a much nearer flight, but to which they seemed to be unequal, as they were obliged, from fatigue, to alight upon the ship, and fall into the hands of the sailors. And Mr. Kalm, another advocate for the torpidity of swallows during the winter, having remarked, however, that he himself had met with them 920 miles from any land; Mr. Barrington endeavours to explain these, and similar facts, by supposing, that birds discovered in such situations, instead of attempting to cross large branches of the ocean, have

[a] Phil. Trans. vol. lxii. p. 265.

been forcibly driven from some coast by storms, and that they would naturally perch upon the first vessel they could see.

In a word, Mr. Barrington is further of opinion, with some other naturalists, that the swallows do not leave this island at the end of autumn, but that they lie in a torpid state, till the beginning of summer, in the banks of rivers, the hollows of decayed trees, the recesses of old buildings, the holes of sand banks, and in similar situations. Among other facts, Mr. Barrington communicated one to Mr. Pennant: "That numbers of swallows have been found in old dry walls, and in sand hills, near the seat of the late lord Belhaven in East Lothian; not once only, but from year to year; and that, when they were exposed to the warmth of a fire, they revived".

These, and other facts of the same kind, are allowed to be uncontrovertible; and Mr. Pennant, in particular, infers from them, "that we must divide our belief relative to these two so different opinions, and conclude, that one part of the swallow-tribe *migrate*, and that others have their winter quarters *near home* [a]".

But there are still more wonderful facts related. Mr. Kalm remarks, that swallows appear in the Jersies about the beginning of April; that, on their first arrival they are wet, because they have just emerged from the sea or lakes, at the bottom of which they had remained in a torpid state during the whole winter [b]. Other naturalists have asserted, that swallows pass the winter immersed under the ice, at the bottom of lakes, or beneath the waters of the sea. Olaus Magnus, archbishop of Upsal, seems to have been the first who adopted this opinion. He informs us, that swallows are found in great clusters at the bottoms of the northern lakes, with

[a] British Zoology, vol. ii. p. 250. 8vo. edit.
[b] Voyage, tome i. p. 24.

mouth to mouth, wing to wing, foot to foot, and that in autumn they creep down the reeds to their subaqueous retreats[a]. In other instances, Mr. Pennant remarks, the good archbishop did not want credulity. But the submersion of the swallows under water does not rest upon his testimony alone. Klein asserts the same; and gives the following account of their manner of retiring, which he collected from some countrymen: "They asserted, that the swallows sometimes assembled in numbers on a reed till it broke, and sunk them to the bottom; that their immersion was preceded by a kind of dirge, which lasted more than a quarter of an hour; that others united, laid hold of a straw with their bills and plunged down in society; that others, by clinging together with their feet, formed a large mass, and in this manner committed themselves to the deep[b]".—Bishop Pontoppidan asserts, that clusters of swallows in their torpid winter state, have sometimes been found by fishermen, among reeds and bushes in lakes; and he charges Mr. Edwards with having, in his Natural History of Birds, groundlessly contradicted this incontestible truth[c].—And Mr. Heerkens, a celebrated Dutch naturalist, in a Latin poem on the Birds of Friesland, speaks in positive terms of the torpid state, and submersion, of the swallows:

Conditur ante hiemem, semestri obnoxia somno,
  Conditur, et variis condita visa locis;
Est, ubi se scopulis per frigora sopit, et antris;
  Est ubi, structuris ruderibusque latet.
Connexus, quandoque vides, rostra indita rostris.
  Est quoque sola, suo quæ jacet orba viro.
Res est mira, latet gelidis quandoque sub undis,
  Ut prope cognatam piscibus esse putes.

a Derham's Physico Theol.
b Klein Prod. Hist. Avium, p. 205.
c Natural History of Norway.

Ere winter his ſomnif'rous power exerts
Six dreary months, the ſwallow-tribes are ſeen
In various haunts concealed; in rocks, and caves,
And ſtructures rude, by cold benum'd, aſleep;
Bill within bill inſerted, cluſt'ring thick:
Or ſolitary ſome, of mate bereft.
But, wonderful to tell! ſome lie immers'd,
Inanimate, beneath the frigid waves,
As if a ſpecies of the finny kinds.

Mr. Heerkens, after reciting many inſtances, and producing in his notes ſeveral authorities, of ſwallows having being found in a torpid ſtate, proceeds, in his poem, to deſcribe very minutely, their aſcent out of the water: The drowſy birds appear on the ſhore, as if unconſcious ſtill of life. Some inhale the ſoft breeze, like one of the finny tribe exiled from its ſtream. Some begin to adjuſt their diſhevelled wings. Others, almoſt revived, eſſay, with buſy bill, to aſſiſt their aged companions. All, at length, reſtored to the unreſtrained uſe of their wings, range, in numerous flights, the aerial way[a].

Two reaſons have been adduced to prove this ſuppoſed ſubmerſion of ſwallows impoſſible. "In the firſt place (ſays Mr. Smellie) no land animal can exiſt ſo long without ſome degree of reſpiration. The otter, the ſeal, and waterfowls of all kinds, when confined under the ice, or entangled in nets, ſoon periſh; yet it is well known, that animals of this kind can remain much longer under water than thoſe who are deſtitute of that peculiar ſtructure of the heart which is neceſſary for any conſiderable reſidence beneath that penetrating element. Mr. John Hunter, in a letter to Mr. Pennant, informs us, 'That he had diſſected many ſwallows, but found nothing in them different from other birds as

[a] Ger. Nicolai Heerkens Groningani Aves Friſicoe, 8vo, Rotterdam 1787.

to the organs of reſpiration: That all thoſe animals which he had diſſected of the claſs that ſleep during the winter, ſuch as lizards, frogs, &c. had a very different conformation as to thoſe organs: That all thoſe animals, he believes, do breathe in their torpid ſtate; and, as far as his experience reaches, he knows they do; and that, therefore, he eſteems it a very wild opinion, that terreſtrial animals can remain any long time under water without drowning'.—Another argument againſt their ſubmerſion ariſes from the ſpecific gravity of the animals themſelves. Of all birds, the ſwallow-tribes are perhaps the lighteſt. Their plumage, and the comparative ſmallneſs of their weight, indicate that Nature deſtined them to be almoſt perpetually on the wing in queſt of food. From this ſpecific lightneſs, the ſubmerſion of ſwallows, and their continuing for months under water, amount to a phyſical impoſſibility. Even waterfowls, when they wiſh to dive, are obliged to riſe and plunge with conſiderable exertion, in order to overcome the reſiſtance of the water. Klein's idea of ſwallows employing reeds and ſtraws as means of ſubmerſion is rather ludicrous; for theſe light ſubſtances, inſtead of being proper inſtruments for aſſiſting them to reach the bottom, would infallibly contribute to ſupport them on the ſurface, and prevent the very object of their intention. Beſides, admitting the poſſibility of their reaching the bottom of lakes and ſeas, and ſuppoſing they could exiſt for ſeveral months without reſpiration, what would be the conſequence? The whole would ſoon be devoured by otters, ſeals, and fiſhes of various kinds. Nature is always anxious for the preſervation of its ſpecies. But, if the ſwallow-tribes were deſtined to remain torpid, during the winter months, at the bottom of lakes and ſeas, ſhe would act in oppoſition to her own intentions; for,

in a ſeaſon or two, the whole genus would be annihilated[a]".

This reaſoning is very ingenious; but, on the other hand, the facts related above are very ſtubborn; and the celebrated Buffon does not heſitate to yield to the force of ſuch ſtrong and concurrent evidence. He had procured ſome chimney ſwallows, and kept them ſome time in an icehouſe, in order to aſcertain whether *they* were of the torpid kind; and he thus relates the reſult of his experiment: "None of them fell into the torpid ſtate: the greater part died, and not one of them revived by being moved into the warmth of the ſun. Thoſe that had not long ſuffered the cold of the icehouſe, had all their movements, and went out briſkly. From theſe experiments I thought I might conclude, that this ſpecies of the ſwallow was not liable to that ſtate of torpor and inſenſibility, which ſuppoſes, notwithſtanding, and very neceſſarily, the fact of its remaining at the bottom of the water during the winter. Having had recourſe, moreover, to the moſt creditable travellers, I found them agreed as to the paſſage of ſwallows over the Mediterranean. And M. Adanſon has poſitively aſſured me, that during the long ſtay he made in Senegal, he obſerved the long-tailed ſwallow, the ſame with the chimney ſwallow we are now ſpeaking of, arrive conſtantly in Senegal about the time it leaves France, and as conſtantly leave Senegal in the ſpring. It cannot, therefore, be doubted, that this ſpecies of the ſwallow paſſes from Europe into Africa in the autumn, and from Africa to Europe in the ſpring; of conſequence it neither ſleeps nor hides itſelf in holes, nor plunges into the water on the approach of winter. There is, beſides, another well authenticated fact, which comes in proof here, and ſhows that this ſwallow is not

[a] Philoſophy of Natural Hiſtory, p. 481.

reduced to a torpid ſtate by cold, which it can bear to a certain degree; and if that degree is exceeded, it dies: for if we obſerve theſe birds toward the end of the warm ſeaſon, we ſhall ſee them, a little before their departure, flying together in families, the father, the mother, and the young brood. Afterward ſeveral families unite, and form themſelves into flocks more or leſs numerous in proportion as the time of their departure draws near. At laſt they go all together, three or four days before the end of September, or about the beginning of October. Still, however, ſome remain, and do not ſet off till a week, a fortnight, or three weeks after the reſt: and ſome too there are which do not go at all, but ſtay and periſh under the firſt rigours of the cold. Theſe ſwallows that delay their flight, or never undertake it, are ſuch as find their young too weak to follow them; ſuch as have had the misfortune to have their neſts deſtroyed after laying, and have been obliged to rebuild them a ſecond or a third time. They ſtay for the love of their little ones, and chooſe rather to endure the rigour of the ſeaſon than to abandon their offspring. Thus they remain ſome time after the reſt for the purpoſe of taking their young with them: and if they are unable to carry them off in the end, they periſh with them.

"Theſe facts then plainly demonſtrate (concludes M. Buffon) that the chimney ſwallows paſs ſucceſſively and alternately from our climate to another that is warmer; that they ſpend their ſummer here, and their winter there; and of conſequence never fall into a ſtate of inſenſibility. But, on the other hand, what have we to oppoſe to the preciſe teſtimony of thoſe who, on the approach of winter, have ſeen theſe ſwallows in troops throw themſelves into the water; nay, not only this, but have ſeen them taken out in neſts from beneath the ice? What anſwer ſhall we make to thoſe who have beheld

them in the torpid ſtate, and ſeen them gradually recover motion and life, when they were brought into the warmth, and moved cautiouſly toward a fire. I know but of one means of reconciling theſe facts. We muſt ſuppoſe that the ſleeping and the travelling ſwallow are of different ſpecies, though the difference, for want of attention, has not been obſerved [a].

Thus this great philoſopher concurs with Mr. Pennant, in his ſolution, already mentioned, of the difficulty, by ſuppoſing two ſpecies—the *migrating* and the *ſleeping* ſwallow. With reſpect to the principal objects of this wonderful inſtinct, that teaches ſuch various kinds of the feathered race to migrate to different countries, it is obvious from what has already been ſaid, that they are food, temperature of air, and convenient ſituations for breeding. I ſhall, therefore, conclude this paper with the following beautiful ſtanzas, from an elegy by Mr. Jago, on their diſappearance from this country:

Through ſacred preſcience, well they know
The near approach of elemental ſtrife;
The bluſtry tempeſt, and the chilling ſnow,
With every want and ſcourge of tender life!

Thus taught, they meditate a ſpeedy flight;
For this ev'n now they prune their vig'rous wing;
For this conſult, adviſe, prepare, excite,
And prove their ſtrength in many an airy ring.

No ſorrow loads their breaſt, or ſwells their eye,
To quit their friendly haunts, or native home;
Nor fear they, launching on the boundleſs ſky,
In ſearch of future ſettlements to roam.

They feel a pow'r, an impulſe all divine!
That warns them hence; they feel it, and obey;
To this direction all their cares reſign,
Unknown their deſtin'd ſtage, unmark'd their way!

[a] Hiſtoire Naturelle des Oiſeaux, tome i.

Well fare your flight! ye mild domeſtic race!
Oh! for your wings to travel with the ſun!
Health brace your nerves, and zephyrs aid your pace,
'Till your long voyage happily be done!

See, Delia, on my roof your gueſts to-day;
To-morrow on my roof your gueſt no more!
Ere yet 'tis night, with haſte they wing away,
To morrow lands them on ſome ſafer ſhore.

How juſt the moral in this ſcene convey'd!
And what without a moral would we read?
Then mark what Damon tells his gentle maid,
And with *his* leſſon regiſter the deed.

'Tis thus life's cheerful ſeaſons roll away;
Thus threats the winter of inclement age;
Our time of action but a ſummer's day:
And earth's frail orb the ſadly-varied ſtage!

And does no pow'r its friendly aid diſpenſe,
Nor give *us* tidings of ſome happier clime?
Find *we* no guide in gracious Providence
Beyond the ſtroke of death, the verge of time?

Yes, yes, the ſacred oracles we hear,
That point the path to realms of endleſs day;
That bid our hearts, nor death, nor anguiſh fear,
This future tranſport, *that* to life the way.

Then let us timely for our flight prepare,
And form the ſoul for her divine abode;
Obey the call, and truſt the Leader's care
To bring us ſafe through virtue's paths to God.

Let no fond love for earth exact a ſigh,
No doubts divert our ſteady ſteps aſide;
Nor let us long to live, nor dread to die;
Heav'n is our hope, and Providence our guide.

LXVII. ON MIGRATION IN GENERAL.

Atque alio patriam quærunt ſub ſole jacentem.

VIRGIL.

Regions they ſeek beneath another ſun.

MIGRATION is generally ſuppoſed to be peculiar to the feathered tribe; but this is a limited idea, which has originated from inattention to the economy of Nature. Birds migrate, with a view to remedy the inconveniencies of their preſent ſituation, and to acquire a more commodious ſtation with regard to food, temperature, propagation, and ſhelter; but, from ſimilar motives, men, ſometimes in amazing multitudes, have migrated from north to ſouth, diſplaced the native inhabitants, and fixed eſtabliſhments in more comfortable climates than thoſe which they had relinquiſhed; and theſe, in their turn, have fallen victims to freſh and barbarous emigrants. Among the inhabitants of the more northern nations, as Norway, Sweden, &c. notwithſtanding a very ſtrong attachment to their native countries, there ſeems to be a natural or inſtinctive propenſity to migrate. Poverty, rigour of climate, curioſity, ambition, falſe repreſentations of intereſted individuals, the oppreſſion of feudal barons, and ſimilar circumſtances, have given riſe to great emigrations of the human ſpecies. But it is worthy of remark, that the emigrations from ſouth to north, except from the love of conqueſt in ambitious nations, are ſo rare, that the inſtinct ſeems hardly to exiſt in thoſe more fortunate climates. Curioſity is a general inſtinctive principle, which operates ſtrongly in the youthful periods of life, and ſtimulates every man to viſit places that are diſtant

from his ordinary reſidence. This innate deſire is influenced by the relations of travellers, and by many other incentives of a more intereſted kind. Without the principle of migration, mankind, it is probable, would never have been ſo univerſally diffuſed over the ſurface of the earth. It is counterbalanced, however, by attachment to thoſe countries which give us birth, a principle ſtill more powerful and efficient. Love of our native country is ſo ſtrong, that, after gratifying the migrating principle, almoſt every man feels a longing deſire to return.

Savages, as long as their ſtore of food remains unexhauſted, continue in a liſtleſs inactive ſtate, and ſeem not to be prompted by any motives of curioſity. They have no conception of a man's walking either for amuſement or exerciſe. But, when their proviſions begin to fail, an aſtoniſhing reverſe takes place. They then rouſe, as from a profound ſleep. In queſt of wild beaſts, birds, and fiſhes, they migrate to immenſe diſtances, exert the greateſt feats of activity, and endure incredible hardſhips and fatigue. After acquiring a ſtore of proviſions, they return to their wonted haunts, and remain inactive till their food begins again to fail.

Quadrupeds likewiſe perform partial migrations. At the approach of winter, the ſtag, the raindeer, and the roebuck, leave the tops of the lofty mountains, and come down to the plains and copſes. Their chief objects, in theſe flittings, are food and ſhelter. When ſummer commences, they are harraſſed with different ſpecies of winged inſects, and to avoid theſe enemies, they regain the ſummits of the mountains, where the cold, and the height of the ſituation, protect them from their attacks. In Norway, and the more northern regions of Europe, the oxen, during the winter, migrate to the ſhores of the ſea, where they feed upon ſea plants and the

bones of fishes; and bishop Pontoppidan remarks, that the cattle know by instinct when the tide retires, and leaves these articles of food upon the shore. In Orkney and Shetland, the sheep, for the same purposes, uniformly repair to the shore, in winter, at the ebbing of the tides. Rats, particularly those of the northern regions of Europe, appear, from time to time, in such myriads, that the inhabitants of Norway and Lapland imagine the animals fall from heaven. The celebrated Linné, who paid great attention to the economy of these migrating rats, remarked, that they appeared in Sweden periodically every eighteen or twenty years. When about to migrate, they leave their wonted abodes, and assemble together in inconceivable numbers. In the course of their journey, they make tracks in the earth of two inches in depth; and these tracks sometimes occupy a breadth of several fathoms. What is singular, the rats in their march, uniformly pursue a straight line, unless they are forced to turn aside by some unsurmountable obstacle. If they meet with a rock, they first try to pierce it, and, after discovering the attempt to be impracticable, they go round it, and then resume the straight line. Even a lake does not interrupt their passage; for they either traverse it in a straight line, or perish in the attempt; and, if they meet with a bark, or other vessel, they do not alter their directions, but climb up the one side of it and descend by the other.

Frogs, immediately after their transformation from the tadpole state, leave the water and migrate to the meadow, or marshy grounds, in quest of insects. The numbers of young frogs which suddenly make their appearance in the plains induced Rondeletius, and many other naturalists, to imagine that they were generated in the clouds, and showered down upon the earth. But if, like Mr. Derham, they had examined the situation of the place with

regard to ſtagnating waters, and attended to the nature and transformation of the animals, they would ſoon have diſcovered the real cauſe of the phenomenon.

Of all migrating animals, particular kinds of fiſhes make the longeſt journies, and in the greateſt numbers. The multiplication of the ſpecies, and the procuring of food, are the principal motives of their migration. The ſalmon, a fiſh which makes regular migrations, frequents the northern regions alone. It is unknown in the Mediterranean ſea, and in all the rivers which fall into it. It is found in ſome of the rivers of France that empty themſelves into the ocean. Salmons are taken in the rivers of Kamtſchatka, and appear as far north as Greenland. They live both in the ocean and in freſh waters. To depoſit their ſpawn, they quit the ſea in the month of September, and aſcend the rivers. So ſtrong is the inſtinct of migrating, that they preſs up the rivers with amazing keenneſs, and ſcarcely any obſtacle is ſufficient to interrupt their progreſs. They ſpring, with great agility, over cataracts ſeveral feet in height. When they find a place which they think proper for depoſiting their eggs, the male and female unite their labours in forming a convenient receptacle for the ſpawn in the ſand, which is generally about eighteen inches deep. In this hole the female depoſits her eggs, and the male his milt, which they are ſaid to cover carefully with their tails; for, after ſpawning, their tails are deprived of ſkin. The eggs, when not diſturbed by violent floods, lie buried in the ſand till the ſpring, and they are hatched about the end of March. The parents, however, after this important office has been performed, haſten back to the ſea, in order to cleanſe themſelves, and to recover their ſtrength. Toward the end of March, the young fry begin to appear, and they gradually increaſe in ſize till they acquire the length

of four or five inches, and are then called ſmelts or ſmoults. About the beginning of May, all the conſiderable rivers of Scotland are full of ſalmon-fry; and, after this period, they migrate to the ſea. About the middle of June, the earlieſt of the fry begin to appear again in the rivers. At that time they are from twelve to ſixteen inches long, and gradually augment, both in number and ſize, till about the end of July or the beginning of Auguſt, when they weigh from ſix to nine pounds. This is a very rapid growth. But a gentleman of credit at Warrington informed Mr. Pennant of a growth ſtill more rapid. A ſalmon, weighing ſeven pounds and three quarters, was taken on the ſeventh day of February. It was marked on the back, fin, and tail, with ſciſſars, and then turned into the river. It was retaken on the 17th day of the following month of March, and then it weighed ſeventeen pounds and a half. The ſeaſon for fiſhing ſalmon in the Tweed begins on the 30th of November, and ends on old Michaelmas day. In that ſingle river, it is computed that no leſs than 208,000, at a medium, are annually caught, which, together with the products of many other rivers on both ſides of Scotland, not only afford a wholeſome and palatable food to the inhabitants, but alſo form a conſiderable article of commerce.

Herrings are likewiſe actuated by the migrating principle. They are chiefly confined to the northern and temperate regions of the globe. They frequent the higheſt latitudes, and are ſometimes found on the northern coaſts of France. They appear in vaſt ſhoals on the coaſt of America, as far ſouth as Carolina. In Cheſapeak bay there is an annual inundation of herrings; and they cover the ſhores in ſuch amazing numbers as to become offenſive to the inhabitants. The great winter rendezvous of the herrings is within, or near, the arctic circle, where they remain ſeveral months, and acquire ſtrength

after being weakened by the fatigues of ſpawning, and of a long migration. In theſe ſeas, inſect food is much more abundant than in warmer latitudes. They begin their migration ſouthward in the ſpring, and appear off Shetland in April and May. Theſe, however, are only the forerunners of the immenſe ſhoal which arrives in June. Their approach is recogniſed by particular ſigns, ſuch as the appearance of certain fiſhes, the vaſt number of birds, as gannets or ſolan geeſe, which follow the ſhoal to prey upon the herrings. But, when the main body arrives, its breadth and depth are ſo great, as to change the appearance of the ocean itſelf. The ſhoal is generally divided into columns of five or ſix miles in length, and three or four in breadth. Their progreſſive motion creates a kind of rippling or ſmall undulations in the water. They ſometimes ſink and diſappear for ten or fifteen minutes, and then riſe again toward the ſurface. When the ſun ſhines, a variety of ſplendid and beautiful colours are reflected from their bodies. In their progreſs ſouthward, the firſt interruption they meet with is from the Shetland iſlands. Here the ſhoal divides into two branches. One branch ſkirts the eaſtern, and the other the weſtern ſhores of Great Britain, and fill every bay and creek with their numbers. Thoſe which proceed to the weſt from Shetland, after viſiting the Hebrides, where the great fiſhery is carried on, move on till they are again interrupted by the north of Ireland, which obliges them to divide a ſecond time. One diviſion takes to the weſt, where they are ſcarcely perceived, being ſoon loſt in the immenſity of the Atlantic ocean. The other diviſion goes into the Iriſh ſea, and affords nouriſhment to many thouſands of the human race. The chief object of herrings migrating ſouthward is to depoſit their ſpawn in warmer and more ſhallow ſeas than thoſe of the frigid zone. This inſtinct ſeems not to be prompted by a ſcarcity of

food; for, when they arrive upon our coaſts, they are fat and in fine condition; but, when returning to the ocean, they are weak and emaciated. They continue in perfection from the end of June to the beginning of winter, when they begin to depoſit their ſpawn. The great ſtations of the herring fiſheries are off the Shetland and the Weſtern iſlands, and along the coaſt of Norfolk.

Beſide ſalmons and herrings, there are many fiſhes which obſerve a regular migration, as mackerels, lampreys, pilchards, &c. About the middle of July, the pilchards, which are a ſpecies of herrings, though ſmaller, appear in vaſt ſhoals off the coaſts of Cornwall. When winter approaches, like the herrings, they retire to the arctic ſeas. Though ſo nearly allied to the herring, it is not incurious to remark, that the pilchards, in their migration for the purpoſe of ſpawning, chooſe a warmer latitude; for, off the coaſts of Britain, the great ſhoals never appear further north than the county of Cornwall and the Scilly iſlands.

Of the land-crab there are ſeveral ſpecies. The migration of what is called the violet land-crab deſerves ſome notice. It inhabits the warmer regions of Europe: but its particular reſidence is in the tropical climates of Africa and America. Land-crabs generally frequent the mountainous parts of the country, which are, of courſe, moſt remote from the ſea. They inhabit the hollows of old trees, the clefts of rocks, and holes which they themſelves dig in the earth. In April and May, they leave the mountains, and march in millions to the ſeaſhore. At this period the whole ground is covered with them; and a man can hardly put down his foot without treading on them [a]. The object of their migration is to depoſit their ſpawn on the ſeaſhore. In their progreſs to-

[a] Voyage aux Iſles Francoiſes pars Labat, tom. ii, page 221.

ward the ſea, like the northern rats, they move in a ſtraight line. Even when a houſe intervenes, inſtead of deviating to the right or left, they attempt to ſcale the walls. But, when they meet with a river, they are obliged to wind along the courſe of the ſtream. In their migration from the mountains, they obſerve the greateſt regularity, and commonly divide into three bodies. The firſt conſiſts of the ſtrongeſt and boldeſt males, which, like pioneers, march forward to clear the way, and to face the greateſt dangers. The females, which form the main body, deſcend from the mountains in regular columns, which are fifty paces broad, three miles long, and ſo cloſe that they almoſt entirely cover the ground. Three or four days afterward, the rear guard follows, which conſiſts of ſtraggling undiſciplined troops of males and females. They travel chiefly during the night; but, if it rain by day (for moiſture facilitates their motion) they proceed in their ſlow uniform manner. When the ſun ſhines, and the ſurface of the ground is dry, they make a univerſal halt till the evening, and then reſume their march. When alarmed with danger, they run backward in a diſorderly manner, and hold up their nippers in a threatening poſture. They even ſeem to intimidate their enemies; for, when diſturbed, they make a clattering noiſe with their nippers. But, though they endeavour to render themſelves formidable to their enemies, they are cruel to each other. When an individual, by any accident, is ſo maimed that he cannot proceed, his companions immediately devour him, and then purſue their journey. After a fatiguing and tedious march, which ſometimes continues three months before they reach the ſhore, they prepare themſelves for depoſiting their ſpawn. The eggs ſtill remain in the bodies of the animals, and are not excluded, as uſual to this genus, under the tail. To facilitate the maturation and excluſion of the

eggs, the land-crabs no ſooner arrive on the ſhore, than they approach to the margin of the ſea, and allow the waves to paſs ſeveral times over their bodies. They immediately retire to the land; the eggs, in the mean time, come nearer to maturity, and the animals once more go to the water, depoſit their eggs, and leave the event to Nature. The bunches of ſpawn are ſometimes as large as a hen's egg; and it is not incurious to remark, that, at this very period, numbers of fiſhes of different kinds are anxiouſly waiting for this annual ſupply of food. Whether the painful migration of the land-crabs, or the wonderful inſtinct of the fiſhes which await their arrival, in order to devour their ſpawn, is the moſt aſtoniſhing fact, muſt be left to the conſideration of philoſophers. The eggs which eſcape theſe voracious fiſhes are hatched under the ſand. Soon after, millions of minute crabs are ſeen leaving the ſhore, and migrating ſlowly toward the mountains. Moſt of the old ones, however, remain in the flat parts of the country till they regain their ſtrength. They dig holes in the earth, the mouths of which they cover with leaves and mud. Here they throw off their old ſhells, remain quite naked, and almoſt without motion for ſix days, when they become ſo fat that they are eſteemed delicious food. When the new ſhell has hardened, the animals, by an inſtinctive impulſe, march back to thoſe mountains which they had formerly deſerted. In Jamaica, where they are numerous, the land-crabs are regarded as great delicacies; and they are ſo abundant, that the ſlaves are often fed entirely upon them.

The migrating principle is not confined to men, quadrupeds, birds, and reptiles: it extends to many of the inſect tribes. Numberleſs inhabitants of the air paſs the firſt ſtages of their exiſtence in the waters. There they remain for longer or ſhorter periods, according to the ſpecies. Previous to their

transformation into chryſaliſes, they quit the waters, and come upon dry ground, where they undergo their amazing change. Inſtead of active water-worms, they dig or find holes in the earth, where they are converted into chryſaliſes, or ſeemingly inanimated beings, and, in a ſhort time, mount into the air in the form of winged inſects. Similar migrations are to be obſerved among land-inſects. But migration is not confined to water-worms. Many ſpecies of caterpillars which feed upon the leaves of trees, ſhrubs, and other vegetables, when about to undergo their transformation, leave their former abodes, deſcend from the trees, and conceal themſelves in the earth. The hiving of bees, when numerous colonies remove in order to eſtabliſh new ſettlements, is another inſtance of the migration of inſects. Indeed, if we except bees, waſps, ants, and a few others, moſt inſects, whether they inhabit the air, earth, or waters, are perfect wanderers, having no fixed place of reſidence. Some of them, as the ſpider tribes, build temporary apartments; but, when diſturbed, they migrate to another commodious place, and erect new habitations.

From the facts which have been enumerated, it is apparent, that the principle of migration, or the deſire of changing ſituations, is not confined to particular birds, but extends through almoſt the whole ſyſtem of animation. Men, quadrupeds, birds, fiſhes, reptiles, inſects, all afford ſtriking examples of the migrating principle. From the ſame facts it is equally apparent, that the general motives for migrating are ſimilar in every claſs of animals. Food, multiplication of ſpecies, and a comfortable temperature of air, are evidently the chief cauſes which induce animals to remove from one place to another, or what amounts to the ſame thing, from one climate to another. Partial emigrations, or emigrations to ſmall diſtances, are prompted by the ſame inſtinctive

motives which induce animals of a different ſtructure to undertake long and fatiguing excurſions. But, previous to actual migration, what are the peculiar feelings of different animals, and what ſhould ſtimulate them to proceed uniformly in the direction that ultimately leads them to the ſituations moſt accommodated to their wants and their conſtitutions, are myſteries, with regard to which, like every other part of the economy of Nature, it is the duty of philoſophers, inſtead of attempting to puſh their inquiries beyond the bounds of human ability, to obſerve a reſpectful ſilence.

LXVIII. ON THE INSTINCT OF BRUTES.

Nor will it leſs delight th' attentive ſage
T' obſerve that inſtinct, which unerring guides
The brutal race, which mimicks reaſon's lore,
And oft tranſcends. SOMERVILE.

This truth ſhines bright to human ſenſe;
Each ſtrong affection of th' unconſcious brute;
Each bent, each paſſion of the ſmalleſt mite,
Is wiſely given; harmonious they perform
The work of perfect reaſon. DYER.

THE Divine Wiſdom and Goodneſs may be ſtill further demonſtrated, not merely from the ſenſes of animals in general, of which I have recently treated, but in the proviſion which he has made for the brute creation in particular, by that wonderful faculty which we call inſtinct; and which I would define to be a natural diſpoſition or ſagacity with which animals are endued, and by virtue of which they are enabled to provide for themſelves, to know what is

good for them, and are determined to propagate and preſerve their ſpecies.

Many of the ancient philoſophers aſcribed to brutes an underſtanding, differing only in degree from that of man, and attributed their inferiority to the want of proper and ſufficient bodily organs. This ſyſtem has been very ſtrenuouſly ſupported by M. Helvetius, in his treatiſe *De l' Eſprit.* Among the moderns, the learned Dr. Cudworth endeavoured to explain the inſtinct of animals, by means of a certain *plaſtic* nature. Des Cartes thought that all the actions of brute animals might be explained by the ſimple laws of mechaniſm. He conſidered them as machines totally devoid of life and ſentiment, but ſo curiouſly conſtructed by the Creator, that the mere impreſſions of light, ſound, and other external agents, on their organs, produced a ſeries of motions on them, and cauſed them to execute thoſe various operations, which had before been aſcribed to a certain principle of life and ſpontaneity. But the actions and manners of animals, which are totally incompatible with the mere principles and laws of mechaniſm, evince the abſurdity of this opinion. The celebrated Buffon, however, adopts it in part; but he allows them life, and the faculty of diſtinguiſhing between pleaſure and pain, together with a ſtrong inclination to the former, and averſion from the latter. By theſe inclinations and averſions, he undertakes to account for all, even the moſt ſtriking operations of animals; affirming that, in conſequence of impreſſions made on the brain, by means of the ſenſitive organs, and by the reaction of the brain and nerves on the muſcles, theſe machines acquire a motion conformable to the nature of the animal, and of the impreſſions of the different objects which act upon their organs, and excite deſire or averſion.

The *pre-eſtabliſhed harmony* of Leibnetz has alſo

been applied to explain the actions of brute animals. Others have considered their actions as produced by the constant and immediate influence of the Divine Energy, directing all their inclinations and motions: such appears to have been the opinion, however unphilosophical it must appear, of Mr. Addison[a]. Abbé de Condillac, in his Essay on the Origin of Human Knowledge, after giving his opinion that brutes have no memory, defines instinct to be—imagination re-exciting, upon the presence of an object, such perceptions as are connected with it, and thereby directing every species of animals, without the assistance of reflection. But all the varieties of opinion on this subject have been accurately enumerated by M. Reimar, in his Observations Physiques, published in 1770. This ingenious philosopher, after defining instinct, in the most comprehensive sense of the word, to be every natural inclination, accompanied with a power, in animals, to perform certain actions, divides instincts into three heads. The first, which he calls *mechanical* instincts, belong to the body, considered as an organized substance, and are exercised blindly and independently of the will of the animal. Such are those which produce the motion of the heart and lungs, the contraction and dilatation of the pupil, digestion, &c. This class of instincts is possessed in common both by men and brutes, and, in some measure, even by vegetables. The second class comprehends those which he terms *representative* in-

[a] "There is not, in my opinion, any thing more mysterious in nature than this instinct in animals, which thus rises above reason, and falls infinitely short of it. It cannot be accounted for by any properties in matter, and, at the same time, it works after so odd a manner, that we cannot think it the faculty of an intellectual being. For my own part, I look upon it as upon the principle of gravitation in bodies, which is not to be explained by any known qualities inherent in the bodies themselves, nor from any laws of mechanism, but, according to the best notions of the greatest philosophers, is *an immediate impression from the First Mover, and the divine energy acting in the creatures.*"

instincts, which consist partly in the power to perceive external objects by their present impression on the senses, and partly by the facility of rendering the ideas of these objects present to the mind by the powers of imagination, or of memory, in a lax sense of the word. These are common to men and other animals, excepting that brutes possess the faculty of imagination only in common with us, and not that of memory, in the strict and proper sense of the word. Indeed, M. Reimar endeavours to prove, that the knowledge of brutes does not merely differ in degree from that of man, but that it is of a kind entirely different from it; and that they are incapable both of memory and reasoning: the faculty of imagination serving to give them a confused idea of events that are past, by the view or other impressions of objects that are present. The third and principal class of instincts is that which comprehends all those which he calls *spontaneous*. This species of instinct is not attended with any power of reflection, determining the animal to decide freely between two different modes of action present to his imagination; nor is it merely corporeal or mechanical. It is put into action by the natural and primitive principle of self-love, implanted in all animated beings; or by a love of pleasure and aversion from pain, producing a voluntary inclination to perform certain actions which tend to their wellbeing and preservation. To the performance of these actions they are particularly prompted by their present sensations, by imagination supplying the place of memory, and by other causes. The wonderful effects produced by these instinctive appetites, are further to be attributed to the exquisite mechanism in their bodily conformation, particularly in the structure of their various organs with which they execute their operations, and to the superior perfection and acuteness of their external senses, by

which they are quickly and diſtinctly informed of thoſe qualities of objects which moſt materially concern them. In order to account for the more curious and ſurpriſing operations of brute animals, M. Reimar adds two other principles; namely, firſt, an internal diſtinct perception of the preciſe power and proper uſe of their various bodily organs, together with an innate knowledge of the qualities of thoſe objects around them in which they are intereſted; and, ſecondly, certain innate and determinate powers and inclinations, impreſſed by the Author of Nature, *à priori*, on the ſoul itſelf; by which they are arbitrarily, and without their own knowledge or conſciouſneſs, directed and irreſiſtibly impelled to the performance of thoſe various operations, which they execute with ſuch unremitting induſtry and art.

I have ſuccinctly ſtated theſe different opinions concerning the inſtinct of brutes, without pretending to determine which is right. There will ever be phenomenons in nature, on which we may reaſon, but on which we cannot decide. The inſtinct of brutes ſeems to have been originally implanted in them by the Great Creator, to compenſate, as it were, for not granting them the nobler faculty of reaſon. Theſe inſtincts are diverſified in a thouſand ways, and appropriated to their reſpective wants. Animals have inſtincts for motion; inſtincts to provide for their ſubſiſtence, to diſcern, to find, to ſeize, and to prepare it; inſtincts to conſtruct their neſts and other habitations; inſtincts for the propagation of their ſpecies, for ſelf-defence, and every other requiſite occaſion. In a word, it ſeems unqueſtionable that inſtinct in brutes bears ſome analogy, however inferior it be, to reaſon in mankind.

Whether with reaſon, or with inſtinct bleſt,
Know, all enjoy that power which ſuits them beſt:
To bliſs alike by that direction tend,
And find the means proportioned to their end.

Say, when full instinct is th' unerring guide,
What pope or council can they need beside?
Reason, however able, cool at best,
Cares not for service, or but serves when prest;
Stays till we call, and then not often near;
But honest instinct is a volunteer,
Sure never to o'ershoot, but just to hit,
While still too wide or short is human wit;
Sure by quick nature happiness to gain,
Which heavier reason labours at in vain.
This too serves always, reason never long:
One must go right, the other may go wrong.
See then the acting aud comparing powers
One in their nature, which are two in ours!
And reason raise o'er instinct as you can,
In this 'tis God directs, in that 'tis man.
Who taught the nations of the field and wood
To shun their poison and to choose their food?
Prescient, the tides and tempest to withstand,
Build on the wave, or arch beneath the sand?
Who made the spider parallels design,
Sure as De Moivre, without rule or line?
Who bid the stork, Columbus-like, explore
Heavens not his own, and worlds unknown before;
Who calls the council, states the certain day,
Who forms the phalanx, and who points the way?

POPE.

From the various instances of the force of instinct in the brute creation, I shall select a few only, which cannot but excite the admiration of the rational observer. This wonderful instinct, whatever it be, directs every different kind of bird to observe a particular plan in the structure of its nest, and directs all the same species to work after the same model. This, certainly, cannot be imitation; for though you hatch a crow under a hen, and never let it see any of the works of its own kind, the nest it makes shall be the same, to the laying of a stick, with all the other nests of the same species. It cannot be

reafon; for were animals endued with it to as great a degree as man, their buildings would be as different as ours, according to the different conveniencies that they would propofe to themfelves.

The force of this inftinct is greater or lefs, in proportion as the particular object of it renders it requifite; for inftance in the propagation of the fpecies. With what caution does the hen provide herfelf a neft in places unfrequented, and free from noife and difturbance! When fhe has laid her eggs in fuch a manner that fhe can cover them, what care does fhe take in turning them frequently, that all parts may partake of the vital warmth! When fhe leaves them, to provide for her neceffary fuftenance, how punctually does fhe return before they have time to cool, and become incapable of producing an animal! In the fummer, you fee her giving herfelf greater liberty, and quitting her care for above two hours together; but in winter, when the rigour of the feafon would chill the principles of life, and deftroy the young ones, fhe grows more affiduous in her attendance, and ftays away but half the time. When the birth approaches, with how much nicety and attention does fhe help the chick to break its prifon! Not to take notice of her covering it from the injuries of the weather, providing it proper nourifhment, and teaching it to help itfelf; nor to mention her forfaking the neft, if, after the ufual time of reckoning, the young one does not make its appearance. A chymical operation could not be followed with greater art or diligence than is feen in the hatching of a chick; although there are many other birds that fhow far greater fagacity in all the forementioned particulars.

But, at the fame time, the hen, which has all this feeming ingenuity (which, indeed, is abfolutely neceffary for the propagation of the fpecies) confidered in other refpects, is without the leaft glimmering of

thought or common ſenſe. She miſtakes a piece of chalk for an egg, and ſits on it in the ſame manner; ſhe is inſenſible of any increaſe or diminution in the number of thoſe ſhe lays: ſhe does not diſtinguiſh between her own, and thoſe of another ſpecies; and when the birth appears of ever ſo different a bird, will cheriſh it for her own. In all theſe circumſtances, which do not carry an immediate regard to the ſubſiſtence of herſelf or her ſpecies, ſhe is a very idiot. In other birds too, the object of this inſtinct appears to be merely the preſervation of their ſpecies: for, notwithſtanding the natural love of brutes is much more violent and intenſe than in rational creatures, Providence has taken care that it ſhall be no longer troubleſome to the parent than it is uſeful to the young; for as ſoon as the wants of the latter ceaſe, the mother withdraws her fondneſs, and leaves them to provide for themſelves: and what is a very remarkable circumſtance in this part of inſtinct, we find that the love of the parent may be lengthened out beyond its uſual time, if the preſervation of the ſpecies require it; as we may ſee in birds that drive away their young as ſoon as ever they are able to get their livelihood, but continue to feed them, if they are tied to the neſt, confined in a cage, or by any other means appear not in a condition to ſupply their own neceſſities.

In the choice of their food, both with reſpect to what is ſalutary, and even what is medicinal, ſheep are particularly ſagacious:

Driv'n oft from nature's path by artful man,
Who blindly turns aſide, with haughty hand,
Whom ſacred inſtinct would ſecurely lead.
By their All-perfect Maſter inly taught,
They beſt their food and phyſic can diſcern;
For He, Supreme Exiſtence, ever near,
Informs them. O'er the vivid green obſerve
With what a regular conſent they crop,

At every fourth collection to the mouth,
Unſavoury crow-flower; whether to awake
Languor of appetite with lively change,
Or timely to repel approaching ills,
Hard to determine. DYER.

Somervile, in the ſecond book of his poem, the Chace, gives a fine deſcription of the inſtinctive ſtratagems, which the roebuck and the hare employ to eſcape from their purſuers.

And others are wonderfully provident in laying up ſtores againſt a time of ſcarcity; as the bee, whoſe hiſtory would alone fill a volume.

But an enumeration of all the powerful operations of inſtinct in the various kinds of animals would carry me too far. Let it ſuffice then, to obſerve here, that man, with all the pride of reaſon, may have been indebted for ſome of the moſt uſeful arts to their ingenious labours; as I have noticed in a former paper[a].

The many wonderful circumſtances obſervable in the inſtinct of brutes, have given riſe to this ſaying of a modern philoſopher, *Deus eſt anima brutorum*, God is the ſoul of brutes; an idea ſimilar, but in a bolder form of words, to that already quoted from Mr. Addiſon. But it is unphiloſophical to attribute that to the *immediate* agency of the Deity, which is the reſult of laws, which he *originally* eſtabliſhed; for he has been pleaſed to govern the material univerſe by the intervention of a variety of ſecond cauſes; all, indeed, under the conſtant guidance of his overruling providence, and all ultimately leading to the contemplation and adoration of Him, the Great Firſt Cauſe and Mover of all.

I ſhall conclude this paper with an excellent argument for a future ſtate, which Dr. Young has deduced from the conſideration of the imperfection

[a] No. LXIII, On the Principles of Aſſociation.

of reaſon in man, and the perfection of inſtinct in brutes.

Reaſon progreſſive, inſtinct is complete;
Swift inſtinct leaps; ſlow reaſon feebly climbs;
Brutes ſoon their zenith reach; their little all
Flows in at once; in ages they no more
Could know, or do, or covet, or enjoy.
Were man to live coëval with the ſun,
The patriarch pupil would be learning ſtill;
Yet, dying, leave his leſſon half unlearnt.
And why?
His *immortality* alone can tell.

LXIX. THE FORCE OF INSTINCT EXEMPLIFIED IN THE NATURAL HISTORY OF THE BEAVER.

Were they as vain as gaudy-minded man,
As flatulent with fumes of ſelf-applauſe,
Their arts too animals might boaſt. YOUNG.

IN my preceding paper I intimated, that the bee, in particular, would furniſh a copious ſubject, illuſtrative of the wonderful force of inſtinct. But as the curious operations of theſe induſtrious inſects are within the reach of actual inſpection, I ſhall be content, at preſent, to have recourſe to the natural hiſtory of the beaver; a creature, whoſe ſagacity is ſo aſtoniſhing, that we may well apply to it what the poet ſays of the elephant:

How inſtinct varies in the groveling ſwine,
Compar'd, half-reaſoning elephant, with thine!
'Twixt that, and reaſon, what a nice barrier!
For ever ſeparate, yet for ever near! POPE.

Of all animals that live in ſociety, none, indeed, approach nearer to human underſtanding than the beavers. We are ſtruck with aſtoniſhment at the ſight of their work; and on reading their hiſtory, are apt to imagine it to be that of a ſpecies of men. We are at a loſs to determine which is moſt wonderful in their labours; whether the grandeur and ſolidity of the undertaking, or the exquiſite art, fine views, and general deſign, ſo excellently diſplayed throughout every part of their execution. A ſociety of beavers ſeems to be an academy of engineers, that proceed on rational plans, which they rectify or modify as they judge neceſſary; purſuing them with exactneſs and perſeverance. They are all actuated by the ſame ſpirit, and unite their will and ſtrength to promote one common end, which is invariably the general good of the ſociety. In a word, we muſt be witneſſes of their performances, before we can imagine them to be capable of them. The traveller that ſhould inſpect their habitations, without previous information, might think himſelf among a nation of ſavages.

The more remote from the tyranny of man, the greater ſeems to be the ſagacity of animals. The beavers, in thoſe diſtant ſolitudes where men have rarely paſſed, exert all the arts of architects and citizens. They build greater habitations than even the rational inhabitants of theſe countries can ſhow, and obey a more regular diſcipline than ever man could boaſt. But as ſoon as man intrudes upon their ſociety, their ſpirit of induſtry and wiſdom ceaſes: they no longer exert their uſual arts, but become patient and dull, as if to fit them for a ſtate of ſervitude.

The American beaver was long unknown to our moſt curious and inquiſitive naturaliſts, or, at leaſt, the accounts we have had were ſo blended with falſehood and error, as to render them altogether of

doubtful authority. The memoirs of the royal academy of ſciences at Paris, and the reſearches, afterward, of the celebrated Buffon, have entirely diſſipated every doubt.

The hair of this animal, which covers the whole body except the tail, is not alike throughout; for there are too ſorts mixed together, which differ not only in length, but in colour and thickneſs. Part of it is about an inch and a half long, and as thick as the hair of a man's head, very ſhining, and of a brown colour, inclining ſomewhat to a tawny. It is of a cloſe ſubſtance, and ſo ſolid, that no cavity can be perceived by a microſcope.—The ſhorteſt is about an inch long, and is in greater plenty than the former: it is likewiſe ſmaller and ſofter, inſomuch that it feels almoſt like ſilk. This difference of the hair or fur is to be met with in ſeveral animals, but more particularly in the beaver, the otter, and the wild boar; which, perhaps, may be the more neceſſary for theſe creatures, becauſe they delight in muddy places, and the longeſt hair may ſerve to keep the mud from penetrating to the ſkin.—The beavers vary in colour. They are ſometimes found of a deep black, eſpecially in the north; and, in the Leverian Muſeum, there is a ſpecimen quite white. As they advance ſouthward, the beauty of their fur decreaſes.—Among the Illinois they are tawny, and even of a ſtraw colour.

The head, from the noſe to the hind part, is five inches and a half long, and five inches broad from the prominence of the two cheek bones. The ears are like thoſe of an otter, being round, and very ſhort: they are covered with hair on the outſide, but are almoſt naked within.—The common length of a beaver, from noſe to tail, is about two feet four inches.

It is commonly ſaid, that theſe animals delight in the gnawing of trees; and, in reality, their teeth ſeem to be very proper for that purpoſe, eſpecially

those before; but they are not sharp-pointed, to serve instead of a saw, as some have affirmed; or, at least, they are not in the American beaver; but they are proper to cut with, like those of squirrels, porcupines, and rats. The length of those below is above an inch; but the upper teeth are not quite so long; and they slip on the side of each other, because they are not directly opposite. They are half round on the outside, and of a bright red or orange colour. They are about a quarter of an inch in breadth near the jaw; but are somewhat narrower at the extremity.—Beside the teeth, called the incisors, they have sixteen grinders, that is, eight on each side, four above and four below, and they are directly opposite to each other.

The structure of their feet is very extraordinary, and evinces evidently, that Nature designed these animals to live as well in the water as on the land: for, although they have four feet like terrestrial animals, yet those behind are as fit for swimming as walking, the five toes of which they consist being joined together like those of a goose, but their fore feet are like the hand of a man. They are covered with hair on the outside, and the nails are long and sharp.

These animals are found in great plenty, all round Hudson's Bay, and as low as Carolina and Louisiana. They are not known in East Florida, nor in South America. Mr. Pennant says, that the species commences in latitude 60, or about the River of Seals, in Hudson's Bay, and is lost in latitude 30, in Louisiana. From Hudson's Bay and Canada, he traces them westward to 120 degrees of longitude, as far as the tract west of Lac Rouge, or the Red Lake. He thinks it probable, that they are continued to the western extremity of this great continent opposite to Asia; for the Russian adventurers got some of their skins on the isle of Radjak, which the

natives muſt have had from America. However, they are certainly not found in the iſlands of the New Archipelago; nor yet in Kamtſchatka, on account of the interruption of woods beyond the river Konyma. From this place, he doubts whether they are to be met with *aſſociated*, or in a *civilized* ſtate, nearer than the banks of the river Jeneſei, or the Konda, and other rivers which run into the Oby. But, in their *unſociable* ſtate, they are found in the woody parts of independant Tartary, in Ruſſia, Lapland, Norway, and Sweden.

The American, or, as we call them, the *aſſociated* and *civilized* beavers, are the moſt ſagacious and induſtrious of animals; and, as obſerved before, they erect edifices ſuperior in contrivance to thoſe of the ſavage human natives of their wilds. In order to form an habitation, they ſelect a level piece of ground, with a ſmall rivulet running through it. To effect their works, a community of two or three hundred aſſemble; and every individual of this community bears his ſhare in the laborious preparations. Some fell trees of great ſize, by gnawing them aſunder with their teeth, in order to form beams or piles; and they ſo contrive, that the tree conſtantly falls toward the water, that they may have the leſs way to carry it, when they have divided it into pieces. After they have done this, they each take a piece by itſelf, and roll it toward the water, where they intend to place it. The expedition with which they cut down theſe trees is amazing; for a number of them ſurround the body, and, in a few minutes, will gnaw through a tree two or three feet in circumference. Others are employed in rolling the pieces to the water; others dive, and ſcrape holes with their feet, in order to fix them; and another party exert their efforts to raiſe them in their proper places. A fifth party is buſied in collecting twiggs to wattle the piles; and a ſixth is collecting earth,

ſtones, and clay, which others carry on their broad tails to their proper places. Theſe beat or temper the earth into mortar with their feet, or ram it between the piles, or plaſter the inſide of their houſes.

Theſe preparations are to form their dwellings within an artificial piece of water or pond, which they make by raiſing a dam acroſs the level ſpot on which they had pitched. This is done, firſt by driving into the ground ſtakes five or ſix feet long, placed in rows, and ſecuring each row by wattling it with twiggs, and filling the interſtices with clay, rammed down cloſe. The ſide next to the water is ſloped; the other perpendicular. The bottom is from ten to twelve feet thick; the thickneſs gradually diminiſhing to the top, which is about two or three feet thick. The centre of the dam forms a ſegment of a circle, from which extends, on each ſide, a ſtraight wing. In the centre of the dam, a gutter is uſually left, for the waſte water to diſcharge itſelf. Theſe dams are often a hundred feet long, and neatly covered with turf.

The houſes which theſe wiſe animals build are ſeated near the ſhore, in the water thus collected by means of the dam. They are erected upon piles, and are ſometimes round, ſometimes oval. The tops are vaulted, ſo that the inſide reſembles an oven, and the outſide a dome. The walls are made of earth, ſtones, and ſticks, and are uſually two feet thick. They are commonly about eight feet high above the ſurface of the water, and are very neatly and cloſely plaſtered in the inſide. The floor is a foot higher than the water. The houſe, ſometimes, has only one floor, which is ſtrowed with leaves or moſs, on which each beaver lies in its proper place. At other times, there are three apartments; one to lodge, a ſecond to eat in, and a third to dung in, for they are very cleanly, and conſtantly cauſe the filth

to be carried off by the inferior beavers.—M. du Pratz ſays, that the beavers in Louiſiana form numbers of cells; and that each animal, or, more probably, each pair, poſſeſſes one. He ſays, that he has ſeen no leſs than fifteen of thoſe cells ſurrounding the centre of one houſe. He alſo acquaints us, that the beavers of Louiſiana are a third leſs than the brown ſort, and that they are covered with a cinereous down, which is covered with long ſilvery hairs.

In each houſe are two openings; one is toward the land; the other is within, and communicates with the water, for the conveniency of getting to their magazine of proviſions in froſty weather. This orifice is formed ſo as to be below the thickneſs of the ice; for they lodge their proviſions under the water, and dive, and bring it into the houſe, as they want it. They begin to build theſe houſes when they form a new ſettlement in the ſummer, and it coſts them a whole ſeaſon to finiſh their work, and to lay in their proviſions.

Theſe beavers ſeem to be among quadrupeds, what bees are among inſects. They have a chief, or ſuperintendant, in their works, who directs the whole; and the utmoſt attention is paid to him by the whole community. Each individual has a taſk allotted, which he undertakes with the utmoſt alacrity. The overſeer gives a ſignal, by a certain number of ſlaps with his tail, expreſſive of his orders. The moment the artificers hear it, they haſten to the place thus pointed out, and perform the allotted labour; whether to draw the wood, to carry the clay, or repair any accidental breach.—They have alſo their centinels among them, who, by the ſame kind of ſignal, give notice of any apprehended danger. They have, moreover, ſays Mr. Graham, a ſort of ſlaviſh beaver among them (ana-

logous to the drone) which they employ in ſervile works, and the domeſtic drudgery.

The number of houſes in each pond is from ten to twenty-five; the number of animals in each from two to thirty. They are ſuppoſed to aſſociate in pairs. They are, therefore, monogamous, which is another proof of their approach to civilization.

Their food, which is laid in before winter, by the tenants of each houſe, conſiſts of the bark and boughs of trees. Mr. Lawſon ſays, that they are fondeſt of the ſaſſafras, aſh, and ſweet gum. In ſummer, they live on leaves, fruit, and ſometimes crabs and crawfiſh: but they are not fond of fiſh.

Their ſagacity in laying in their winter proviſion is wonderful. They cut the wood they prefer into certain lengths; they pile them in heaps beneath the water, to keep them moiſt; and when they want food, they bite the wood into ſmall pieces, and bring it into their houſes. Father Charlevoix ſays, that the Indians obſerve the quantity which the beavers lay in at the approach of winter; and that it is the almanack of the ſavages, who judge, from the greater or leſs ſtock, of the ſeverity or mildneſs of the approaching ſeaſon.

The beavers of America have a variety of lakes and waters, in which they might fix their ſeats; but their ſagacity informs them of the precarious tenure of ſuch dwellings, which are liable to be overthrown by every flood. This is their inducement for undertaking their vaſt and wonderful labours, in places where no ſuch inconvenience can be felt. Having, therefore, formed a dam, as before obſerved, to ſupport a reſervoir, fed only by a rivulet, they have nothing to fear but from land floods, or the ſudden melting of the ſnows. Theſe, ſometimes, make breaches, or damage their houſes; but the defects are inſtantly repaired.

In a word, ſo wonderful is the ſagacity, the ſkill, and the labours of beavers, that, as M. Bonnet obſerves, they will ever remain an impenetrable enigma to philoſophers. They are endued, he thinks, with a kind of underſtanding, which ſeems to place them between man and other animals. Their works, indeed, bear the greateſt reſemblance to thoſe of man; and were we to judge of them from their firſt impreſſion upon us, we ſhould be apt to conclude that theſe animals were actually endued with underſtanding and reflection. But, from a cloſer inſpection, it will appear, that in all their architecture, they are not actuated by reflection, but by that inſtinct which is innate in them. Were they capable of reflection, they might build very differently now from what they did formerly; and we ſhould perceive, in their habitations, the traces of greater perfection, and continual improvement. But we may perceive, that they adhere invariably to their ancient methods; and that they never depart from the circle which nature has preſcribed to them. The beavers, therefore, build no otherwiſe now, than they did before the deluge.—This, however, cannot diminiſh our admiration of them; for of all the animals that live in ſociety, theſe, certainly, approach the neareſt to human reaſon; and they leave us, in aſtoniſhment, to exclaim with the poet of the Seaſons,

What is this Mighty Breath, ye ſages, ſay,
That in a powerful language, felt, not heard,
Inſtructs them?

LXX. ON THE HABITATIONS OF ANIMALS IN GENERAL.

Behold the acting and comparing powers
One in their nature, which are two in ours!
And reason raise o'er instinct as you can,
In this 'tis God directs, in that 'tis man. POPE.

INSTINCTIVE ingenuity, in the construction of their habitations, is not confined to insects: it is visible, for the same common ends, in the admirable contrivances of quadrupeds and birds. In some former papers, I entered into a discussion of instinct in general [a], exemplified by the natural history of the beaver [b], and by some observations on the nidification of birds [c]; and I shall devote my present essay to some considerations on the habitations of animals in general.

With regard to quadrupeds, many of them employ no kind of architecture, but live constantly in the open air. When not under the immediate protection of man, they shelter themselves in rough, or stormy weather, among trees or bushes, or retire under the coverture of projecting rocks, or the sides of hills opposite to those from which the wind proceeds. Beside these arts of defence, to which they are prompted by instinct and experience, Nature furnishes them, during the winter months, with a double portion of long hair, which protects them from cold, and other assaults of the weather.

Of the quadrupeds that make or choose habitations for themselves, some dig holes in the earth, some take refuge in the cavities of decayed trees, and in the clefts of rocks, and some actually construct cabins or houses. But the artifices they employ,

[a] No. LXVIII. [b] No. LXIX. [c] No. LXIV.

the materials they uſe, and the ſituations they ſelect, are ſo various, and ſo numerous, that I am neceſſarily confined to a few of the more curious examples.

Of the operations and architecture of the beaver, I have already, as obſerved above, given a very ample account. The Alpine marmot is a quadruped about ſixteen inches in length, and has a ſhort tail. In figure, the marmots have ſome reſemblance both to the rat and to the bear. When tamed, they eat every thing preſented to them; as fleſh, bread, fruit, roots, herbs, inſects, &c. They delight in the regions of froſt and ſnow, and are only to be found on the tops of the higheſt mountains. They remain in a torpid ſtate during winter. About the end of September or beginning of October, they retire into their holes, and never come abroad again till the beginning of April. Their retreats are formed with much art and precaution. With their feet and claws, which are admirably adapted to the purpoſe, they dig the earth with amazing quickneſs, and throw it behind them. They do not make a ſimple hole, or a ſtraight or winding tube, but a kind of gallery in the form of a Y, each branch of which has an aperture, and both terminate in a capacious apartment, where ſeveral of the animals lodge together. As the whole operation is performed on the declivity of a mountain, this innermoſt apartment is alone horizontal. Both branches of the Y are inclined. One of the branches deſcends under the apartment, and follows the declivity of the mountain. This branch is a kind of aqueduct, and receives and carries off the excrements of the animals; and the other, which riſes above the principal apartment, is uſed for coming in and going out. The place of their abode is well lined with moſs and hay, of which they lay up great ſtore during the ſummer. They are ſocial animals. Several of them live together, and

work in common when forming their habitations. Thither they retire during rain, or upon the approach of danger. One of them ſtands centinel upon a rock, while the others gambol upon the graſs, or are employed in cutting it, in order to make hay. If the centinel perceives a man, an eagle, a dog, or other dangerous animal, he alarms his companions by a loud whiſtle, and is himſelf the laſt that enters the hole. As they continue torpid during winter, and, as if they foreſaw that they would then have no occaſion for victuals, they lay up no proviſions in their apartments. But, when they feel the firſt approaches of the ſleeping ſeaſon, they ſhut up both paſſages to their habitation; and this operation they perform with ſuch labour and ſolidity, that it is more eaſy to dig the earth any where elſe than in ſuch parts as they have thus fortified. At this time they are very fat, weighing ſometimes twenty pounds. They continue to be plump for three months; but afterward they gradually decline, and, at the end of winter, are extremely emaciated. When ſeized in their retreats, they appear rolled up in the form of a ball, and covered with hay. In this ſtate, they are ſo torpid that they may be killed without ſeeming to feel pain. The hunters ſelect the fatteſt for eating, and keep the young ones for taming. Like the dormice, and all the other animals which ſleep during winter, the marmots are revived by a gradual and gentle heat: and it is remarkable, that thoſe which are fed in houſes, and kept warm, never become torpid, but are equally active and lively during the whole year.

The habitation where moles depoſit their young merits a particular deſcription; becauſe it is conſtructed with peculiar intelligence, and becauſe the mole is an animal with which we are well acquainted. They begin by raiſing the earth, and forming a pretty high arch. They leave partitions, or a

kind of pillars, at certain diſtances, beat and preſs the earth, interweave it with the roots of plants, and render it ſo hard and ſolid, that the water cannot penetrate the vault, on account of its convexity and firmneſs. They then elevate a little hillock under the principal arch; upon the latter they lay herbs and leaves for a bed to their young. In this ſituation they are above the level of the ground, and, of courſe, beyond the reach of ordinary inundations. They are, at the ſame time, defended from the rains by the large vault that covers the internal one, upon the convexity of which laſt they reſt along with their young. This internal hillock is pierced on all ſides with ſloping holes, which deſcend ſtill lower, and ſerve as ſubterraneous paſſages for the mother to go in queſt of food for herſelf and her offſpring. Theſe by-paths are beaten and firm, extend about twelve or fifteen paces, and iſſue from the principal manſion like rays from a centre. Under the ſuperior vault we likewiſe find remains of the roots of the meadow ſaffron, which ſeem to be the firſt food given to the young. From this deſcription it appears, that the mole never comes abroad but at conſiderable diſtances from her habitation. Moles, like the beavers, pair; and ſo lively and reciprocal an attachment ſubſiſts between them, that they ſeem to diſreliſh all other ſociety. In their dark abodes they enjoy the placid habits of repoſe and ſolitude, the art of ſecuring themſelves from injury, of almoſt inſtantaneouſly making an aſylum or habitation, and of procuring a plentiful ſubſiſtence without the neceſſity of going abroad. They ſhut up the entrance of their retreats, and ſeldom leave them, unleſs compelled by the admiſſion of water, or when their manſions are demoliſhed by art.

The nidification of birds has at all times deſervedly called forth the admiration of mankind. Their neſts, in general, are built with ſuch exquiſite art,

that an exact imitation of them exceeds all the powers of human ſkill. Their ſtyle of architecture, the materials they employ, and the ſituations they ſelect, are as various as the different ſpecies. Individuals of the ſame ſpecies, whatever region of the globe they inhabit, collect the ſame materials, arrange and conſtruct them in the ſame form, and make choice of ſimilar ſituations for erecting their temporary habitations; for the neſts of birds, thoſe of the eagle-kind excepted, after the young have come to maturity, are for ever abandoned by the parents.

To deſcribe minutely the neſts of birds would be a vain attempt. Such deſcriptions could not convey an adequate idea of their architecture to a perſon who had never ſeen one of thoſe beautiful and commodious habitations, which even aſtoniſh and excite the amazement of children.

The different orders of birds exhibit great variety in the materials and ſtructure of their neſts. Thoſe of the rapacious tribes are in general rude, and compoſed of coarſe materials, as dried twigs, bents, &c. But they are often lined with ſoft ſubſtances. They build in elevated rocks, ruinous and ſequeſtered caſtles and towers, and in other ſolitary retirements. The aërie or neſt of the eagle is quite flat, and not hollow, like thoſe of other birds. The male and female commonly place their neſt between two rocks, in a dry and inacceſſible ſituation. The ſame neſt, it is ſaid, ſerves the eagle during life. The ſtructure is ſo conſiderable, and compoſed of ſuch ſolid materials, that it may laſt many years. Its form reſembles that of a floor. Its baſis conſiſts of ſticks about five or ſix feet in length, which are ſupported at each end, and theſe are covered with ſeveral layers of ruſhes and heath. An eagle's neſt was found in the Peak of Derbyſhire, which Willoughby deſcribes in the following manner: "It was made of great

ſticks, reſting one end on the edge of a rock, the other on a birch tree. Upon theſe was a layer of ruſhes, and over them a layer of heath, and on the heath ruſhes again; upon which lay one young, and an addle egg; and by them a lamb, a hare, and three heath pouts. The neſt was about two yards ſquare, and had no hollow in it". But the butcher-birds, or ſhrikes, which are leſs rapacious than eagles and hawks, build their habitations in ſhrubs and buſhes, and employ moſs, wool, and other ſoft materials.

The birds belonging to the order of Pies in Mr. Pennant's Genera of Birds, are extremely irregular in conſtructing their neſts. The common magpies build their neſts in trees, and their ſtructure is admirably contrived for affording warmth and protection to the young. The neſt is not open at top: it is covered, in the moſt dexterous manner, with an arch or dome, and a ſmall opening in the ſide of it is left, to give the parents an opportunity of paſſing in and out at their pleaſure. To protect their eggs and young from the attacks of other animals, the magpies place, all round the external ſurface of their neſt, ſharp briars and thorns. The long-tailed titmouſe, or oxeye, builds nearly like the wren, but with ſtill greater art. With the ſame materials as the reſt of the ſtructure, the titmouſe builds an arch over the top of the neſt, which reſembles an egg erected upon one end, and leaves a ſmall hole in the ſide for a paſſage. Both eggs and young, by this contrivance, are defended from the injuries of the air, rain, cold, &c. That the young may have a ſoft and warm bed, ſhe lines the inſide of the neſt with feathers, down, and cobwebs. The ſides and roof are compoſed of moſs and wool interwoven in the moſt curious and artificial manner.

I have mentioned before [a], that, in warm climates,

[a] See No. LXIV.

many ſmall birds ſuſpended their neſts on tender twigs of trees, to prevent them from being deſtroyed by the monkeys. In Europe, there are only three birds which build penſile neſts, namely, the common oriola, the *parus pendulinus*, or hang-neſt titmouſe; and another penſile neſt, belonging to ſome unknown bird, was lately diſcovered by Mr. Pennant, near the houſe of Blair in Athole, in the north of Scotland. In a ſpruce fir-tree, Mr. Pennant remarks [a], was a hang-neſt of ſome unknown bird, ſuſpended at the four corners to the boughs. It was open at top, an inch and a half diameter, and two deep; the ſides and bottom thick; the materials moſs, worſted, and birch bark, lined with feathers.

It is a ſingular, though a well atteſted fact, that the cuckow makes no neſt, and neither hatches nor feeds her own young. "The hedge-ſparrow (ſays Mr. Willoughby) is the cuckow's nurſe, but not the hedge-ſparrow only, but alſo ringdoves, larks, finches. I myſelf, with many others, have ſeen a wagtail feeding a young cuckow. The cuckow herſelf builds no neſt; but having found the neſt of ſome little bird, ſhe either devours or deſtroys the eggs ſhe there finds, and, in the room thereof, lays one of her own, and ſo forſakes it. The ſilly bird returning, ſits on this egg, hatches it, and, with a great deal of care and toil, broods, feeds, and cheriſhes the young cuckow for her own, until it be grown up and able to fly and ſhift for itſelf. Which thing ſeems ſo ſtrange, monſtrous, and abſurd, that for my part I cannot ſufficiently wonder there ſhould be ſuch an example in Nature; nor could I ever have been induced to believe that ſuch a thing had been done by Nature's inſtinct, had I not with mine own eyes ſeen it. For Nature, in other things, is wont conſtantly to obſerve one and the ſame law and order,

[a] Tour in Scotland, vol. i. page 104.

agreeably to the higheſt reaſon and prudence; which in this caſe is, that the dams make neſts for themſelves, if need be, ſit upon their own eggs, and bring up their own young after they are hatched [a]". This economy, in the hiſtory of the cuckow, is not only ſingular, but ſeems to contradict one of the moſt univerſal laws eſtabliſhed among animated beings, and particularly among the feathered tribes, namely, the hatching and rearing of their offspring. Still, however, like the oſtrich in very warm climates, though the cuckow neither hatches nor feeds her young, ſhe places her eggs in ſituations where they are both hatched and her offspring brought to maturity. Here the ſtupidity of the one animal makes it a dupe to the rapine and chicane of the other; for the cuckow always deſtroys the eggs of the ſmall bird before ſhe depoſits her own.

Moſt of the paſſerine or ſmall tribes build their neſts in hedges, ſhrubs, or buſhes; though ſome of them, as the lark and the goatſucker, build upon the ground. The neſts of ſmall birds are more delicate in their ſtructure and contrivance than thoſe of the larger kinds. As the ſize of their bodies, and likewiſe that of their eggs, are ſmaller, the materials of which their neſts are compoſed are generally warmer. Small bodies retain heat a ſhorter time than thoſe which are large. Hence the eggs of ſmall birds require a more conſtant ſupply of heat than thoſe of greater dimenſions. Their neſts, accordingly, are built proportionally warmer and deeper, and they are lined with ſofter ſubſtances. The larger birds, of courſe, can leave their eggs for ſome time with impunity; but the ſmaller kinds ſit moſt aſſiduouſly; for, when the female is obliged to go abroad in queſt of food, the neſt is always occupied by the male. When a neſt is finiſhed, nothing can exceed the

a Willoughby's Ornithology, page 98.

dexterity of both male and female in concealing it from the obſervation of man, and of other deſtructive animals. If it is built in buſhes, the pliant branches are diſpoſed in ſuch a manner as to hide it entirely from view. To conceal her retreat, the chaffinch covers the outſide of her neſt with moſs, which is commonly of the ſame colour with the bark of the tree on which ſhe builds. The common ſwallow builds its neſt on the tops of chimnies; and the martin attaches hers to the corners of windows, or under the eaves of houſes. Both employ the ſame materials. The neſt is built with mud well tempered by the bill, and moiſtened with water to make it more firmly cohere; and the mud or clay is kept ſtill firmer by a mixture of ſtraw or graſs. Within it is neatly lined with feathers. Willoughby, on the authority of Bontius, informs us, "That, on the ſeacoaſt of the kingdom of China, a ſort of ſmall party-coloured birds, of the ſhape of ſwallows, at a certain ſeaſon of the year, namely, their breeding time, come out of the midland country to the rocks; and from the foam or froth of the ſea water daſhing and breaking againſt the bottom of the rocks, gather a certain clammy, glutinous matter, perchance the ſperm of whales, or other fiſhes, of which they build their neſts. Theſe neſts the Chineſe pluck from the rocks, and bring them in great numbers into the Eaſt Indies to ſell; which are eſteemed by gluttons great delicacies, who, diſſolving them in chicken or mutton broth, are very fond of them, preferring them far before oyſters, muſhrooms, or other dainty and lickeriſh morſels which moſt gratify the palate. —Theſe neſts are of a hemiſpherical figure, of the bigneſs of a gooſe-egg, and of a ſubſtance reſembling iſinglaſs [a]".

Moſt of the cloven-footed waterfowls, or waders, lay their eggs upon the ground. But the ſpoonbill

a Willoughby's Ornithology, page 215.

and the common heron build large neſts in trees, and employ twigs and other coarſe materials; and the ſtorks build on churches, or on the tops of houſes. Many of the webfooted fowls lay their eggs likewiſe on the ground, as the terns, and ſome of the gulls and merganſers. But ducks pull the down from their own breaſts to afford a warmer and more comfortable bed for their young. The auks, the guillemots, and the puffins, lay their eggs on the naked ſhelves of high rocks. The penguins, for the ſame purpoſe, dig large and deep holes under ground.

It is not unworthy of remark, that birds uniformly proportion the dimenſions of their neſts to the number and ſize of the young to be produced. Every ſpecies lays nearly a determined number of eggs. But, if one be each day abſtracted from the neſt, the bird continues to lay daily more till her number is completed. Dr. Liſter, by this practice, made a ſwallow lay no leſs than nineteen eggs.

Innumerable other particulars might be adduced of the force of inſtinct in the brute creation, with reſpect to their habitations. But enow have been enumerated, to evince how much the providential care of the Divine Being is extended over univerſal exiſtence.—I ſhall conclude this paper with the obſervations of an ingenious writer [a], on the beaver, in particular, which are well worthy the attention of the proud politicians of the human race, who are now ſo warmly contending concerning the origin and progreſs, the ſubverſion and regeneration, or perhaps extinction of empires:

"Next to the intelligence exhibited in human ſociety, that of the beavers is the moſt conſpicuous. Their operations in preparing, faſhioning, and tranſporting the heavy materials for building their winter habitations, are truly aſtoniſhing; and, when we read their hiſtory, we are apt to think that we are

[a] Smellie, in his Philoſophy of Natural Hiſtory.

perusing the history of man in a period of society not inconsiderably advanced. It is only by the united strength, and co-operation of numbers, that the beavers could be enabled to produce such wonderful effects; for, in a solitary state, as they at present appear in some northern parts of Europe, the beavers, like solitary savages, are timid and stupid animals. They neither associate, nor attempt to construct villages, but content themselves with digging holes in the earth. Like men under the oppression of despotic governments, the spirit of the European beavers is depressed, and their genius is extinguished by terror, and by a perpetual and necessary attention to individual safety. The northern parts of Europe are now so populous, and the animals there are so perpetually hunted for the sake of their furs, that they have no opportunity of associating; of course, those wonderful marks of their sagacity, which they exhibit in the remote and uninhabited regions of North America, are no longer to be found. The society of beavers is a society of peace and of affection. They never quarrel or injure one another, but live together in different numbers, according to the dimensions of particular cabins, in the most perfect harmony. The principle of their union is neither monarchical nor despotic. But the inhabitants of the different cabins, as well as those of the whole village, seem to acknowledge no chief or leader whatever. Their association presents to our observation a model of a pure and perfect republic, the only basis of which is mutual and unequivocal attachment. They have no law but the law of love and of parental affection. Humanity prompts us to wish that it were possible to establish republics of this kind among mankind. But the dispositions of men have little affinity to those of the beavers".

LXXI. ON THE INSTINCT OF AFFECTION IN THE BRUTE CREATION.

'Tis love creates their melody, and all
This waste of music is the voice of love;
That even to birds, and beasts, the tender arts
Of pleasing teaches. THOMSON.

Is it for thee the linnet pours his throat?
Loves of his own and raptures swell the note.
POPE.

THE great intention of Nature, in endowing almost every animal with a sexual attachment, is the multiplication and continuation of the respective species. But, with regard to man, and, in an inferior degree, to all pairing animals, love is the source of many other social and important advantages. Love, or a strong affection for a particular woman, is to young men, perhaps, one of the greatest incentives to virtue and propriety of conduct. This observation, however, I shall not pursue, as it is more properly the subject of a moral essay. My present disquisition, in course, shall be confined to that instinct of Nature in the brute creation, taught by which, they form reciprocal attachments, and evince the most powerful and uncontrollable affection for their young.

The love of offspring, though not universal, is, perhaps, the strongest and most active principle in nature. It overcomes the sense of pain, and even the principle of self-preservation. Among many wonderful examples of this, may be mentioned that of a bitch, which, during the operation of dissection, licked her young, whose presence seemed to make her forget the most excruciating tortures; and,

when they were removed, ſhe uttered the moſt dolorous cries [a].—Certain ſpecies of ſpiders incloſe their eggs in a ſilken bag ſpun and wove by themſelves. This bag they fix to their back, and carry it along with them wherever they go. They are extremely nimble in their motions. But, when the bag is forced from a ſpider of this kind, her natural agility forſakes her, and ſhe falls into a languid ſtate. When the bag is again preſented to her, ſhe inſtantly ſeizes it, and carries it off with rapidity. The young ſpiders no ſooner eſcape from the eggs than they dexterouſly arrange themſelves on the back of the mother, who continues, for ſome time, to carry them about with her, and to ſupply all their wants. Another ſpecies of ſpider attaches her bag of eggs to her belly. This ſpider is likewiſe very agile, and ſo ferocious and determined in the protection of her eggs, that ſhe has been known to ſuffer death rather than relinquiſh them.—The hind ſpontaneouſly preſents herſelf to be chaſed by the dogs, to prevent them from attacking her fawn.—When the fox perceives that her young have been diſturbed in her abſence, ſhe carries them off, one after another, and conceals them in a new retreat.—Waſps feed their young, when in the worm or caterpillar ſtate, in the ſame manner as pigeons and other birds that diſgorge. The pigeon, after ſwallowing grain, retains it for ſome time in her ſtomach, till it is ſoftened and macerated: ſhe then diſgorges, and throws it into the mouths of her young. "In the ſame manner (ſays Reaumur) I have obſerved a female waſp ſwallow a large portion of an inſect: in a ſhort time afterward, ſhe traverſed the different cells of her neſt, diſgorged the contents of her ſtomach, and diſtributed food in this half digeſted form to her young worms".

[a] Smellie's Philoſophy of Natural Hiſtory.

All animals acquire a double portion of force and courage after they bring forth. A cow, at leaſt in a domeſtic ſtate, is a placid and phlegmatic animal: but, whenever ſhe produces a calf, a wonderful change is exhibited: ſhe inſtantly becomes vigilant, active, and even ferocious, in the defence of her young. A lioneſs deprived of her cubs preſents the moſt dreadful picture of anxiety, rage, and rapacity. Deſcending lower in the ſcale of animation, the ſame change is to be remarked. A domeſtic hen is a timid, indocile, and obſtinately ſtupid creature. Though chaſed, haraſſed, and even put in danger of her life, fifty times in a day, ſhe never learns to avoid a garden, or any particular place which ſhe is accuſtomed to frequent, or to which ſhe is led by her appetite for food: but, the moment her chicken are hatched, inſtead of her uſual timidity, ſhe becomes as bold as a lion. When ſhe thinks her young are in danger, ſhe briſtles up her feathers, aſſumes a fierceneſs in her eye, makes an alarming noiſe, and attacks, in the moſt furious manner, and without diſtinction, every animal that comes near her. By the ſuddenneſs of her onſets, ſhe often alarms men, and actually intimidates and beats off dogs, and other animals, that could devour her in an inſtant.

Though ſeveral of the inſect tribes diſcover a ſtrong attachment to their young, yet all thoſe which undergo transformations, and do not form ſocieties, muſt be completely ignorant of the exiſtence of their progeny; becauſe, in general, the parents die before the young are hatched. Nature, however, has endowed thoſe ſpecies with an inſtinct which produces all the effects of parental affection: they uniformly depoſit their eggs in ſubſtances which afford to the young, immediately after their eſcape from the egg, a nouriſhment adapted to their reſpective conſtitutions, and a comfortable and ſafe protection from injury. Thus Nature, ever attentive to the conti-

nuation and happineſs of her productions, however ſeemingly inſignificant in the ſcale of being, often employs very different means to accompliſh the ſame beneficent purpoſes.

Nature has unqueſtionably attached pleaſure to all the neceſſary functions of animals. But this pleaſure cannot be conſidered as the original cauſe of any particular action; for the experiment muſt be made before the animal can diſcover whether the reſult is to be agreeable or diſagreeable. The truth is, that Nature has beſtowed on the minds of all animated creatures a number of laws or inſtincts perfectly accommodated to the ſpecies, and which irreſiſtibly compel them to perform certain actions. The effects of theſe laws we perceive: but the cauſes, or the modes by which they operate on animal minds, are inſcrutable. We may and muſt admire, but we can never penetrate the myſteries of Nature.

Marriage, or pairing, though by no means a univerſal inſtitution of Nature, is not unfrequently exhibited in the animal creation. In the feathered race, for inſtance, the ſame impulſe, or law of Nature, takes place among the partridge tribes, the ſwallows, the linnets, and, in general, all the ſmall birds. The aſſiduity, attention, mutual affection, laborious vigilance, and ſtedfaſt fidelity of pairing animals, are truly admirable, and, to ingenious minds, afford the moſt exemplary admonitions to virtue and conjugal attachment. Indeed, in general, it is to be remarked, that all thoſe ſpecies of animals, whoſe offspring require, for ſome time, the induſtry and ſupport of both parents, are endowed with the inſtinct of ſelection, or of pairing. With regard to the feathered tribes, pairing is almoſt univerſal. A diſtinction, however, as to the duration and circumſtances of their pairing, is to be obſerved. The young of all the ſmall birds, as well as of moſt of the larger kinds, continue for ſome weeks in a

weak and helpleſs condition. The mother is not, like quadrupeds, provided with organs fitted to ſecrete milk; of courſe, ſhe is unable to nouriſh them out of her own body. She is therefore obliged to go abroad in queſt of food for them. But the progeny are ſo numerous, that all her induſtry, if not aſſiſted by the father, would be ineffectual for their ſupport and protection. In all birds whoſe young are in this condition, the males and females not only pair, but each of them is endowed with the ſtrongeſt parental affection. Both are equally anxious and induſtrious in procuring food for their mutual offſpring. This parental care and attachment uniformly continues till the young are fledged, and have acquired ſufficient ſtrength to provide for themſelves. Eagles, and ſome other birds of prey, continue faithfully in pairs for years, and perhaps during life. Theſe facts afford a ſtrong argument in favour of marriage among mankind. No animal remains ſo long in the infant and helpleſs ſtate as the children of men; and no mother could, with her own induſtry, poſſibly ſuckle and procure nouriſhment for a numerous family. Here, as in the feathered tribes, the aſſiſtance of the father becomes indiſpenſable. On this ſubject, a curious inſtinct merits attention. The male of moſt birds not only ſelects a female, but, with great aſſiduity, brings food to her when ſitting on her eggs, and often relieves her by ſitting on them himſelf.

I cannot forbear, in this place, to illuſtrate my ſubject, by ſome beautiful paſſages from Thomſon, that accurate obſerver, and enthuſiaſtic admirer, of rural nature;

The gloſſy kind
Try every winning way inventive love
Can dictate, and in courtſhip to their mates
Pour forth their little ſouls,

Connubial leagues agreed, to the deep woods
They haste away, all as their fancy leads,
Pleasure, or food, or secret safety prompts;
That Nature's great command may be obey'd,
Nor all the sweet sensations they perceive
Indulg'd in vain.

The patient dam assiduous sits,
Not to be tempted from her tender task,
Or by sharp hunger, or by smooth delight,
Though the whole loosen'd Spring around her blows.
Her sympathizing lover takes his stand
High on th' opponent bank, and ceaseless sings
The tedious time away; or else supplies
Her place a moment, while she sudden flits
To pick the scanty meal. Th' appointed time
With pious toil fulfill'd, the callow young,
Warm'd and expanded into perfect life,
Their brittle bondage break, and come to light,
A helpless family, demanding food
With constant clamour: O what passions then,
What melting sentiments of kindly care,
On the new parents seize! Away they fly
Affectionate, and undesiring bear
The most delicious morsel to their young;
Which equally distributed, again
The search begins.

Nor toil alone they scorn: exalting love,
By the great Father of the Spring inspir'd,
Gives instant courage to the *fearful* race,
And to the *simple* art. With stealthy wing,
Should some rude foot their woody haunts molest,
Amid a neighbouring bush they silent drop,
And whirring thence, as if alarm'd, deceive
Th' unfeeling schoolboy. Hence, around the head
Of wandering swain, the white-wing'd plover wheels
Her sounding flight, and then directly on
In long excursion skims the level lawn,
To tempt him from her nest. The wild-duck, hence,

O'er the rough moſs, and o'er the trackleſs waſte
The heath-hen flutters, pious fraud! to lead
The hot purſuing ſpaniel far aſtray.

But now the feather'd youth their former bounds,
Ardent, diſdain; and, weighing oft their wings,
Demand the free poſſeſſion of the ſky:
This one glad office more, and then diſſolves
Parental love at once, now needleſs grown.
Unlaviſh Wiſdom never works in vain.
'Tis on ſome evening, ſunny, grateful, mild,
When nought but balm is breathing through the woods,
With yellow luſtre bright, that the new tribes
Viſit the ſpacious heavens, and look abroad
On nature's common, far as they can ſee,
Or wing, their range and paſture. O'er the boughs
Dancing about, ſtill at the giddy verge
Their reſolution fails; their pinions ſtill,
In looſe libration ſtretch'd, to truſt the void
Trembling refuſe: till down before them fly
The parent-guides, and chide, exhort, command,
Or puſh them off. The ſurging air receives
Its plumy burden; and their ſelf-taught wings
Winnow the waving element. On ground
Alighted, bolder up again they lead,
Further and further on, the lengthening flight;
Till, vaniſh'd every fear, and every power
Rouz'd into life and action, light in air
Th' acquitted parents ſee their ſoaring race,
And once rejoicing never know them more.

The careful hen
Calls all her chirping family around,
Fed and defended by the fearleſs cock;
Whoſe breaſt with ardour flames, as on he walks,
Graceful, and crows defiance. In the pond,
The finely checker'd duck, before her train,
Rows garrulous. The ſtately-ſailing ſwan
Gives out his ſnowy plumage to the gale;
And, arching proud his neck, with oary feet
Bears forward fierce, and guards his oſier iſle,

Protective of his young. The turkey nigh,
Loud-threatening reddens; while the peacock ſpreads
His ever-colour'd glory to the ſun,
And ſwims in radiant majeſty along.
O'er the whole homely ſcene, the cooing dove
Flies thick in amorous chaſe, and wanton rolls
The glancing eye, and turns the changeful neck.

It would exceed the limits of this paper, if I were to extend my obſervations to quadrupeds, among whom pairing does not univerſally take place. There is one circumſtance, however, which I cannot paſs unnoticed, as it diſplays, in the moſt conſpicuous view, the over-ruling care of Providence; namely, that in the brute creation, with ſome few exceptions, the ſeaſons of love are limited to particular times of the year. Theſe ſeaſons, though various, are admirably adapted to the nature and economy of the different ſpecies. They are ſo contrived, as well as the time of geſtation, that the offspring, when brought forth, are amply ſupplied with the particular ſpecies of food upon which they principally live. To inſtance in the feathered race, the young of pairing birds are produced in the ſpring, when the weather begins to be comfortably warm, and their natural food abounds. In a word, the bringing forth, or hatching, of all animals, not excluding the inſect tribes, uniformly takes place at thoſe ſeaſons of the year when the nature of the weather, and the food peculiar to the ſpecies, are beſt adapted to the conſtitution of their offspring. Caterpillars of every kind are never hatched till the various plants on which they feed, though they grow in different months, have put forth their leaves.

LXXII. ON THE ARTIFICES OF VARIOUS KINDS OF ANIMALS.

One portion of informing fire was given
To brutes, th' inferior family of Heaven.

DRYDEN.

For He, Supreme Exiſtence, ever near,
Informs them.

DYER.

HAVING treated lately on the principle of aſſociation, and the inſtinct of affection, as they pervade the brute creation, I ſhall cloſe my obſervations on animals in general, with ſome inſtances of the wonderful artifices which various kinds of them employ, either for ſelf-preſervation, or the protection of their young.

Many of theſe arts are purely inſtinctive, and others are acquired by experience and imitation. The love of life, the deſire of multiplying and continuing the ſpecies, and that ſtrong attachment which every animal has to its offspring, are the ſources from which we muſt trace all the movements, dexterity, and ſagacity of animals. The principle of ſelf-preſervation is ſtrongly impreſſed upon the minds of all animated beings. It gives riſe to innumerable arts of attack and defence, and not unfrequently to ſurpriſing exertions of ſagacity and genius.

When cattle are attacked by a bear, or other rapacious animal, they inſtantly form a phalanx for mutual defence. In the ſame circumſtances, horſes rank up in lines, and beat off the enemy with their heels. Biſhop Pontoppidon relates, that the ſmall Norwegian horſes, when attacked by bears, inſtead of ſtriking with their hind legs, rear, and, by quick and repeated ſtrokes with their fore-feet, either kill

the enemy, or oblige him to retire. This curious, and generally ſucceſsful defence, is frequently performed in the woods, while a traveller is ſitting on the horſe's back. When the Norwegian horſe, moreover, at ſuch a juncture, has a mare or gelding with him, he generouſly puts them behind him, while he attacks the bear with his fore-legs; but if he ſhould turn about to kick with his hind-legs, he is ruined, the bear, which has double his ſtrength, inſtantly leaping, and fixing on his back, when the poor horſe gallops on, till he drops down from the loſs of blood [a]. It has often been remarked, that troops of wild horſes, when ſleeping, have always one of their number awake, who acts as a centinel, and gives notice of approaching danger.

The monkeys in Brazil, while they are ſleeping on the trees, have uniformly a centinel to warn them of the approach of the tiger or other rapacious animals; and, if ever this centinel is found ſleeping, his companions inſtantly tear him in pieces for his neglect of duty. For the ſame purpoſe, when a troop of monkeys are committing depredations on the fruits of a garden, a centinel is placed on an eminence, who, when any perſon appears, makes a chattering noiſe, when the reſt immediately make their eſcape.

The deer-kind are remarkable for the arts they employ in order to deceive the dogs. With this view the ſtag often returns twice or thrice upon his former ſteps. He endeavours to raiſe hinds or younger ſtags to follow him, and to draw off the dogs from the immediate object of their purſuit. If he ſucceeds in this attempt, he then flies off with redoubled ſpeed, or ſprings off at a ſide, and lies down on his belly to conceal himſelf. When in this ſituation, if by any means his foot is recovered by

[a] Natural Hiſtory of Norway, folio 1755.

the dogs, they purſue him with more advantage, becauſe he is now conſiderably fatigued. Their ardour increaſes in proportion to his feebleneſs; and the ſcent becomes ſtronger as he grows warm. From theſe circumſtances the dogs augment their cries and their ſpeed; and, though the ſtag employs more arts of eſcape than formerly, as his ſwiſtneſs is diminiſhed, his doublings and artifices become gradually leſs effectual. No other reſource is now left him but to fly from the earth which he treads, and go into the waters, in order to cut off the ſcent from the dogs, when the huntſmen again endeavour to put them on the track of his foot. After taking to the water, the ſtag is ſo much exhauſted, that he is incapable of running much further, and is ſoon *at bay*, or, in other words, turns and defends himſelf againſt the hounds. In this ſituation he often wounds the dogs, and even the huntſmen, by blows with his horns, till one of them cuts his hams to make him fall, and then puts a period to his life.

The fallow-deer is more delicate, and approaches nearer to the domeſtic ſtate than the ſtag. The males, during the rutting ſeaſon, make a bellowing noiſe, but with a low and interrupted voice. They are not ſo furious as the ſtag. They never depart from their own country in queſt of females; but they bravely fight for the poſſeſſion of their miſtreſſes. They aſſociate in herds, which generally keep together. When great numbers are aſſembled in one park, they commonly form themſelves into two diſtinct troops, which ſoon become hoſtile, becauſe they are both ambitious of poſſeſſing the ſame part of the incloſure. Each of theſe troops has its own chief or leader, who always marches foremoſt, and he is uniformly the oldeſt and ſtrongeſt of the flock. The others follow him; and the whole draw up in order of battle, to force the other troop, who obſerve the ſame conduct, from the beſt paſture. The regula-

rity with which these combats are conducted is singular. They make regular attacks, fight with courage, and never think themselves vanquished by one check; for the battle is daily renewed till the weaker are completely defeated, and obliged to remain in the worst pasture. They love elevated and hilly countries. When hunted, they run not straight out, like the stag, but double, and endeavour to conceal themselves from the dogs by various artifices, and by substituting other animals in their place. When fatigued and heated, however, they take the water, but never attempt to cross such large rivers as the stag. Thus, between the chace of the fallow-deer and of the stag, there is no material difference. Their sagacity and instincts, their shifts and doublings, are the same, only they are more frequently practised by the fallow-deer. As he runs not so far before the dogs, and is less enterprising, he has oftener occasion to change, to substitute another in his place, to double, and to return upon his former tracks, which renders the hunting of the fallow-deer more subject to inconveniencies than that of the stag.

The roebuck is inferior to the stag and fallow-deer both in strength and stature; but he is endowed with more gracefulness, courage, and vivacity. His eyes are more brilliant and animated. His limbs are more nimble; his movements are quicker, and he bounds with equal vigour and agility. He is likewise more crafty, conceals himself with greater address, and derives superior resources from his instincts. Though he leaves behind him a stronger scent than the stag, which increases the ardour of the dogs, he knows how to evade their pursuit, by the rapidity with which he commences his flight, and by his numerous doublings.

Heaven-taught, the roebuck swift
Loiters at ease before the driving pack,

And mocks their vain purſuit: nor far he flies,
But checks his ardour, till the ſteaming ſcent,
That freſhens on the blade, provokes their rage.
Urg'd to their ſpeed, his weak deluded foes,
Soon flag fatigued; ſtrain'd to exceſs each nerve,
Each ſlacken'd ſinew fails; they pant; they foam;
Then o'er the lawn he bounds, o'er the high hills
Stretches ſecure, and leaves the ſcatter'd crowd
To puzzle in the diſtant vale below. SOMERVILE.

Hares poſſeſs not, like rabbits, the art of digging retreats in the earth. But they neither want inſtinct ſufficient for their own preſervation, nor ſagacity for eſcaping their enemies.

'Tis inſtinct that directs the jealous hare
To chooſe her ſoft abode. With ſteps revers'd
She forms the doubling maze; then, ere the morn
Peeps through the clouds, leaps to her cloſe receſs.
As wandering ſhepherds on the Arabian plains
No ſettled reſidence obſerve, but ſhift
Their moving camp; now, on ſome cooler hill
With cedars crown'd, court the refreſhing breeze;
And then, below, where trickling ſtreams diſtil
From ſome precarious ſource, their thirſt allay,
And feed their fainting flocks: So the wiſe hares
Oft quit their ſeats, leſt ſome more curious eye
Should mark their haunts, and by dark treacherous wiles
Plot their deſtruction; or perchance in hopes
Of plenteous forage, near the ranker mead,
Or matted blade, wary and cloſe they ſit.
When ſpring ſhines forth, ſeaſon of love and joy,
In the moiſt marſh, 'mong beds of ruſhes hid,
They cool their boiling blood. When ſummer ſuns
Bake the cleft earth, to thick wide-waving fields
Of corn full-grown, they lead their helpleſs young;
But when autumnal torrents and fierce rains
Deluge the vale, in the dry crumbling bank
Their forms they delve, and cautiouſly avoid
The dripping covert. Yet when winter's cold
Their limbs benumbs, thither with ſpeed return'd

In the long graſs they ſkulk, or ſhrinking creep,
Among the wither'd leaves, thus changing ſtill,
As fancy prompts them, or as food invites.

SOMERVILE.

The fox has, in all ages and nations, been celebrated for craftineſs and addreſs:

For all his father's wiles the fox retains. WEST.

Acute and circumſpect, ſagacious and prudent, he diverſifies his conduct, and always reſerves ſome art for unforeſeen accidents. Though nimbler than the wolf, he truſts not entirely to the ſwiftneſs of his courſe. He knows how to enſure ſafety, by providing himſelf with an aſylum, to which he retires when danger appears. He is not a vagabond, but lives in a ſettled habitation and in a domeſtic ſtate. The choice of ſituation, the art of making and rendering a houſe commodious, and of concealing the avenues which lead to it, imply a ſuperior degree of ſentiment and reflection. The fox poſſeſſes theſe qualities, and employs them with dexterity and advantage. He takes up his abode on the border of a wood, and in the neighbourhood of cottages. Here he liſtens to the crowing of the cocks and the noiſe of the poultry. He ſcents them at a diſtance. He chooſes his time with great judgement and diſcretion. He conceals both his route and his deſign. He moves forward with caution, ſometimes even trailing his body, and ſeldom makes a fruitleſs expedition. When he leaps the wall, or gets in underneath it, he ravages the court-yard, puts all the fowls to death, and then retires quietly with one of them, which he either conceals under the herbage, or carries off to his kennel. In a ſhort time he returns for another, which he carries off and hides in the ſame manner, but in a different place. In this manner he proceeds, till the light of the ſun, or

ſome movements perceived in the houſe, admoniſh him that it is time to retire to his den. He does much miſchief to the birdcatchers. Early in the morning he viſits their nets and their birdlime, and carries off ſucceſſively all the birds that happen to be entangled. The young hares he hunts in the plains, ſeizes old ones in their ſeats, digs out the rabbits in the warrens, finds out the neſts of partridges, quails, &c. ſeizes the mothers on the eggs, and deſtroys a prodigious number of game. When purſued he runs to his hole; and it is not uncommon to ſend in terriers to detain him till the hunters remove the earth above, and either kill or ſeize him alive. The moſt certain method, however, of deſtroying a fox is to begin with ſhutting up the hole, to ſtation a man with a gun near the entrance, and then to ſearch about with the dogs. When they fall in with him, he immediately makes for his hole. But, when he comes up to it, he is met with a diſcharge from the gun. If the ſhot miſſes him, he flies off with full ſpeed, takes a wide circuit, and returns again to the hole, where he is fired upon a ſecond time; but when he diſcovers that the entrance is ſhut, he darts away ſtraight forward, with the intention of never reviſiting his former habitation. He is next purſued by the hounds, whom he ſeldom fails to fatigue; becauſe, with much cunning, he paſſes through the thickeſt part of the foreſt, or places of the moſt difficult acceſs, where the dogs are hardly able to follow him; and, when he takes to the plains, he runs ſtraight out, without either ſtopping or doubling. He is an exceedingly voracious animal. Beſide all kinds of fleſh and fiſhes, he devours eggs, cheeſe, fruits, and particularly grapes. He is ſo extremely fond of honey, that he attacks the neſts of wild bees. They at firſt put him to flight by numberleſs ſtings; but he retires for the ſole purpoſe of rolling himſelf on the ground,

and of cruſhing the bees. He returns to the charge ſo often, that he obliges them to abandon the hive, which he ſoon uncovers, and devours both the honey and the wax. Some time before the female brings forth, ſhe retires, and ſeldom leaves her hole, where ſhe prepares a bed for her young. When ſhe perceives that her retreat is diſcovered, and that her young have been diſturbed, ſhe carries them off, one by one, into a new habitation. The fox ſleeps in a round form, like the dog; but, when he only repoſes himſelf, he lies on his belly with his hind-legs extended. It is in this ſituation that he eyes the birds on the hedges and trees. The birds have ſuch an antipathy againſt him, that they no ſooner perceive him than they ſend forth ſhrill cries to advertiſe their neighbours of the enemy's approach. The jays and blackbirds, in particular, follow the fox from tree to tree, ſometimes two or three hundred paces, often repeating the watch-cries. The count de Buffon kept two young foxes, which, when at liberty, attacked the poultry; but, after they were chained, they never attempted to touch a ſingle fowl. A living hen was fixed near them for whole nights; and, though deſtitute of victuals for many hours, in ſpite of hunger and of opportunity, they never forgot that they were chained, and gave the hen no diſturbance.

In Kamtſchatka, the animals called *gluttons* employ a ſingular ſtratagem for killing the fallow-deer. They climb up a tree, and carry with them a quantity of that ſpecies of moſs of which the deer are very fond. When a deer approaches near the tree, the glutton throws down the moſs. If the deer ſtops to eat the moſs, the glutton inſtantly darts down upon its back, and, after fixing himſelf firmly between the horns, tears out its eyes, which torments the animal to ſuch a degree, that, whether to put an end to its torments, or to get rid of its cruel enemy, it ſtrikes its

head againſt the trees till it falls down dead. The glutton divides the fleſh of the deer into convenient portions, and conceals them in the earth to ſerve for future proviſions. The gluttons on the river Lena kill horſes in the ſame manner.

A ſpecies of rats in Kamtſchatka make neat and ſpacious neſts under ground. Theſe are lined with turf, and divided into different apartments, in which the rats depoſit ſtores of proviſions for their ſupport during the winter. It is worthy of remark, that the rats of this country never touch the proviſions laid up for the winter, except when they cannot procure nouriſhment any where elſe. Theſe rats, like the Tartars, change their habitations. Sometimes they totally abandon Kamtſchatka for ſeveral years, and their retreat greatly alarms the inhabitants, which they conſider as a preſage of a rainy ſeaſon, and of a bad year for hunting. The return of theſe animals is, of courſe, looked upon as a good omen. Whenever they appear, the happy news is ſoon ſpread over all parts of the country. They always take their departure in the ſpring, when they aſſemble in prodigious numbers, and traverſe rivers, lakes, and even arms of the ſea. After they have made a long voyage, they frequently lie motionleſs on the ſhore, as if they were dead. When they recover their ſtrength they recommence their march. The inhabitants of Kamtſchatka are very ſolicitous for the preſervation of theſe animals. They never do the rats any injury, but give them every aſſiſtance when they lie weakened and extended on the ground. They generally return to Kamtſchatka about the month of October; and they are ſometimes met with in ſuch prodigious numbers, that travellers are obliged to ſtop two hours till the whole troop paſſes. The track of ground they travel in a ſingle ſummer is not leſs wonderful than the regularity they obſerve in their march, and that inſtinctive impulſe which en-

ables them to foreſee, with certainty, the changes of times and of ſeaſons.

With regard to birds, their artifices are not leſs numerous nor leſs ſurpriſing than thoſe of quadrupeds. The eagle and hawk kinds are remarkable for the ſharpneſs of their ſight and the arts they employ in catching their prey. Their movements are rapid or ſlow, according to their intentions, and the ſituation of the animals they wiſh to devour. Rapacious birds uniformly endeavour to riſe higher in the air than their prey, that they may have an opportunity of darting forcibly down upon it with their pounces. To counteract theſe artifices, Nature has endowed the ſmaller and more innocent ſpecies of birds with many arts of defence. When a hawk appears, the ſmall birds, if they find it convenient, conceal themſelves in hedges or bruſhwood. When deprived of this opportunity, they often, in great numbers, ſeem to follow the hawk, and to expoſe themſelves unneceſſarily to danger, while, in fact, by their numbers, their perpetual changes of direction, and their uniform endeavour, to riſe above him, they perplex the hawk to ſuch a degree, that he is unable to fix upon a ſingle object; and, after exerting all his art and addreſs, he is frequently obliged to relinquiſh the purſuit. When in the extremity of danger, and after employing every other artifice in vain, ſmall birds have been often known to fly to men for protection.

The ravens often frequent the ſeaſhore in queſt of food. When they find their inability to break the ſhells of muſcles, &c. they uſe a very ingenious ſtratagem: they carry a muſcle, or other ſhellfiſh, high up in the air, and then daſh it down upon a rock, by which means the ſhell is broken.

The woodpecker is furniſhed with a very long and voluble tongue. It feeds upon ants and other ſmall inſects. Nature has endowed this bird with a ſingular inſtinct. It knows how to procure food

without ſeeing its prey. It attaches itſelf to the trunks or branches of decayed trees; and, wherever it perceives a hole or crevice, it darts in its long tongue, and brings it out loaded with inſects of different kinds. This operation is certainly inſtinctive; but the inſtinct is aſſiſted by the inſtruction of the parents; for the young are no ſooner able to fly, than the parents, by the force of example, teach them to reſort to trees, and to inſert their tongues indiſcriminately into every hole or fiſſure.

Of the economy of fiſhes, our knowledge is extremely limited. But, as the ocean exhibits a perpetual and a general ſcene of attack and defence, the arts of aſſault and of evaſion muſt, of courſe, be exceedingly various.

The inſect tribes, though comparatively diminutive, are not deficient in artifice and addreſs. But I ſhall only mention the *formica-leo*, or ant-lion, which is a ſmall inſect, ſomewhat reſembling a wood-louſe, but larger. Its head is flat, and armed with two fine moveable crotchets or pincers. It has ſix legs, and its body, which terminates in a point, is compoſed of a number of membraneous rings. In the ſand, or in finely pulveriſed earth, this animal digs a hole in the form of a funnel, at the bottom of which it lies in ambuſh for its prey. As it always walks backward, it cannot purſue any inſect. To ſupply this defect, it lays a ſnare for them, and eſpecially for the ant, which is its favourite food. It generally lies concealed under the ſand in the bottom of its funnel or trap, and ſeldom exhibits more than the top of its head. In digging a funnel, the formica-leo begins with tracing a circular furrow in the ſand, the circumference of which determines the ſize of the funnel, which is often an inch deep. After the firſt furrow is made, the animal traces a ſecond, which is always concentric with the firſt. It throws out the ſand, as with a ſhovel, from the

ſucceſſive furrows or circles, by means of its ſquare flat head and one of its fore-legs. It proceeds in this manner till it has completed its funnel, which it does with ſurpriſing promptitude and addreſs. At the bottom of this artful ſnare it lies concealed and immoveable. When an ant happens to make too near an approach to the margin of the funnel, the ſides of which are very ſteep, the fine ſand gives way, and the unwary animal tumbles down to the bottom. The formica-leo inſtantly kills the ant, buries it under the ſand, and ſucks out its vitals. It afterward puſhes out the empty ſkin, repairs the diſorder introduced into its ſnare, and again lies in ambuſh for a freſh prey. When arrived at its full growth, the formica-leo gives up the buſineſs of an enſnaring hunter. He deſerts his former habitation, and crawls about for ſome time on the ſurface of the earth. He at laſt retires under the ground, ſpins a round ſilken pod, and is ſoon transformed into a fly.

LXXIII. ON THE INTERNAL STRUCTURE OF THE EARTH.

Sit mihi fas——— ——— ———
Pandere res altâ terrâ et caligine merſas. VIRGIL.

Give me, ye powers, the wondrous ſcenes to ſhow
Conceal'd in darkneſs, in the depths below.

ON the ſurface of our globe, we have contemplated the Divine Power and Goodneſs, in innumerable inſtances, in which beauty and uſefulneſs are equally apparent. Let us now penetrate into its interior regions, and explore the wonders of creative power in its dark receſſes.

The philoſopher has extended his *ideal* reſearches to the very centre of the Earth; but *actual* inquiries have proceeded, hitherto, but a very little depth below its ſurface; and, even in theſe inquiries, the ſpirit of enterprize has been excited more by motives of avarice than of curioſity. The deepeſt mine, which is that of Cotteberg in Hungary [a], extends only to the depth of 3000 feet: but what proportion does this bear to the depth of the globe, down to its centre, which is about 4000 miles? Whatever, therefore, has been ſaid of the Earth, to a greater depth, is mere fiction or conjecture. We may ſuppoſe it, with Buffon, to be a globe of glaſs; with Whiſton, a ſphere of heated iron; with Burnet, a great maſs of waters; and, with Kircher, one dreadful volcano; but we muſt ever, at the ſame time, confeſs, that thoſe are ſuppoſitions, which can never be aſcertained by any human being.

Upon examining the Earth, where it has been opened to any depth, the firſt thing that occurs, is the different layers or beds of which it is compoſed. All theſe lie horizontally over each other, like the leaves of a book, and each of them is compoſed of materials that increaſe in weight in proportion as they lie deeper. This is, in general, the diſpoſition of the different materials, where the Earth ſeems to have been unmoleſted; but this order is frequently inverted, either from its original formation, or from accidental cauſes.

The firſt layer, moſt commonly found at the ſurface, is that light coat of blackiſh mould, which is called, by ſome, garden earth. With this the Earth is univerſally inveſted, unleſs it be waſhed away by rains, or removed by ſome other external violence. This ſeems to have been formed from animal and

[a] Boyle, vol. iii, page 240.

vegetable bodies decaying, and thus turning into its ſubſtance. It ſerves alſo as a ſtorehouſe, whence the animal and vegetable natures are renewed; and thus are all the vital bleſſings continued in unceaſing circulation. This earth, however, is not to be ſuppoſed entirely pure, but is mixed with much ſtony and gravelly matter, from the layers that lie immediately beneath it. It generally happens, that the ſoil is fertile, in proportion to the quantity which this putrefied mould bears to the gravelly mixture; and as the former predominates, ſo far is the vegetation upon it more luxuriant. It is this external covering that ſupplies man with all the true riches he enjoys. He may bring up gold or precious ſtones from greater depths; but they are merely the toys of a capricious being, upon which he has placed an imaginary value, and for which he often exchanges the more ſubſtantial bleſſings of life. "It is this earth (ſays Pliny) which, like a kind mother, receives us at our birth, and ſuſtains us when born. It is this alone, of all the elements around us, that is never found an enemy to man. The body of waters may deluge him with rain, oppreſs him with hail, and drown him with inundations. The air ruſhes in ſtorms, prepares the tempeſt, or lights up the volcano; but the earth, gentle and indulgent, ever ſubſervient to the wants of man, ſpreads his walks with flowers, and his table with plenty; returns with intereſt every good committed to her care; and if ſhe produce the poiſon, ſhe ſupplies alſo the antidote. Though conſtantly teaſed, more to ſupply the wants of man than his neceſſities, yet, even to the laſt, ſhe continues her kind indulgence, and, when life is over, piouſly covers his remains in her boſom [a]".

This external and prolific layer is in a ſtate of

[a] Hiſt. Nat. lib. ii. cap. 63.

continual change. Vegetables, which are naturally fixed and rooted to the ſame place, receive their adventitious nouriſhment from the ſurrounding air and water: animals which remove from place to place, are ſupported by theſe, or by each other. Both, however, having enjoyed, for a time, a life adapted to their nature, return to the earth thoſe ſpoils which they had borrowed for a very ſhort ſpace, yet ſtill to be quickened again into exiſtence. But the depoſits they make are of very diſſimilar kinds, and the earth is differently enriched by their continuance. Thoſe countries that have, for a long time, ſupported men and other animals, have been obſerved to become more barren every day; while, on the contrary, thoſe deſolate places, in which vegetables only are abundantly produced, are known to be poſſeſſed of amazing fertility. "In regions which are uninhabited (ſays Buffon) where the foreſts are not cut down, and animals do not feed upon the plants, the bed of vegetable earth is conſtantly increaſing. In all woods, and even in thoſe often cut, there is a layer of earth of ſix or eight inches thick, formed by leaves, branches, and bark, that fall and rot upon the ground. I have frequently obſerved on a Roman way, which croſſes Burgundy, for a long extent, that there is a bed of black earth, of more than a foot thick, gathered over the ſtony pavement, on which ſeveral trees, of a very conſiderable ſize, are ſupported. This I have found to be nothing but the earth formed by the decayed leaves and branches, which have been converted by time into a black ſoil. Now as vegetables draw much more of their nouriſhment from the air and water than they do from the earth, it muſt follow, that, in rotting upon the ground, they give much more to the ſoil than they have taken from it. Hence, therefore, in woods kept a long time without cutting, the ſoil below increaſes to a conſiderable depth; and ſuch we actually

find in those American wilds where the forests have been undisturbed for ages. But it is otherwise where men and other animals have long subsisted; for, as they make a considerable consumption of wood and plants, both for firing and other uses, they take more from the earth than they return to it. It follows, therefore, that the bed of vegetable earth, in an inhabited country, must be always diminishing, and must, at length, resemble the soil of Arabia Petræa, and other oriental countries, which, having been long inhabited, are now become plains of salt and sand; the fixed salt always remaining, while the other volatile parts have flown away[b]".

If, from this external surface, we descend deeper, and view the Earth cut perpendicularly downward, either in the banks of great rivers, or steepy sea-shores; or, going still deeper, if we observe it in quarries or mines, we shall find its layers regularly disposed in their proper order. We must not expect, however, to find them of the same kind or thickness in every place, as they differ in different soils and situations. Sometimes, marle is seen to be over sand, and sometimes, under it. The most common disposition is, that under the first earth is found gravel or sand, then clay or marle, then chalk or coal, marbles, ores, sands, gravels; and thus an alternation of these substances, each growing more dense as it sinks deeper. The clay, for instance, found at the depth of one hundred feet, is commonly more heavy than that found near the surface.

Of these beds over beds it is still more remarkable, that each of them, as far as it extends, maintains exactly the same thickness. It is found, also, that, as we proceed to considerable depths, every layer grows thicker. They are sometimes very extensive, being found often to cover a space of many

[a] Buffon, vol. i, page 353.

leagues in circumference. But it muſt not be ſuppoſed, that they are uniformly continued over the whole globe, without interruption: on the contrary, they are ever, at ſmall intervals cracked through, as it were, by perpendicular fiſſures; the earth reſembling, in this reſpect, the muddy bottom of a pond, whence the water has been dried off by the ſun, and thus gaping in ſeveral chinks, which deſcend in a direction perpendicular to its ſurface. Theſe fiſſures are many times found empty, but are often cloſed up by adventitious ſubſtances, which the rain or ſome other accidental cauſes, have conveyed to their cavities. Their openings are not leſs different than their contents, ſome being not above half an inch wide, ſome a foot, and ſome ſeveral yards aſunder; which laſt form thoſe dreadful chaſms that are to be found in the Alps, at the edge of which the traveller ſtands, dreading to look down to the immeaſurable gulf below. Theſe amazing clefts are well known to ſuch as have paſſed thoſe mountains, where a chaſm frequently appears ſeveral hundred feet deep, and as many over, at the edge of which the way lies. It often happens alſo, that the roads lead along the bottom, and then the ſpectator obſerves, on each ſide, frightful precipices ſeveral hundred feet above him; the ſides of which correſpond ſo exactly with each other, that they ſeem evidently torn aſunder.

But the chaſms in the Alps are nothing to what are to be ſeen in the Andes in America. Theſe amazing mountains, in compariſon of which the former are but little hills, have their fiſſures in proportion to their greatneſs. In ſome places, they are a mile wide, and deep in proportion; and there are ſome others, that running under ground, reſemble, in extent, a province [a].

Of this kind alſo is the cavern called Elden Hole in Derbyſhire; which, Dr. Plott tells us, was

[a] Goldſmith's Hiſtory of the Earth, vol. i. ch. 6.

ſounded by a line of 2800 feet, without finding the bottom, or meeting with water; and yet the mouth of it is not above forty yards over [a]. This immeaſurable chaſm runs perpendicularly downward; and the ſides of it ſeem to tally ſo plainly, as to ſhow that they were once united. Thoſe who viſit the chaſm generally procure ſtones to be thrown into its mouth; and theſe are heard for ſome time, falling and ſtriking againſt its ſides, producing a ſound like diſtant thunder, dying away as the ſtone falls deeper.

There are many more of theſe dreadful perpendicular fiſſures in different parts of the Earth, with accounts of which Kircher, Gaffarellus, and others, who have given hiſtories of the wonders of the ſubterranean world, abundantly ſupply us. The generality of readers, however, will conſider them with leſs aſtoniſhment, when they are informed of their being common all over the Earth; that in every field, in every quarry, theſe perpendicular fiſſures are to be found; either ſtill gaping, or filled with matter that has accidentally cloſed their interſtices. The inattentive ſpectator neglects the inquiry; but their being common is partly the cauſe that excites the philoſopher's attention to them. The irregularities of Nature he is often content to paſs over unexamined; but when a conſtant and common appearance is preſented, every return of the object is a freſh call to his curioſity, and the chink in the next quarry becomes as great a matter of wonder as the chaſm in Elden Hole. Philoſophers, therefore, have long endeavoured to find out the cauſe of theſe perpendicular fiſſures, which our own countrymen, Woodward and Ray, were the firſt who obſerved them to be ſo common and univerſal. Buffon ſuppoſes them to be cracks made by the ſun, in drying up the earth, immediately after its emerging from the deep. The heat of the ſun is very pro-

[b] Philoſophical Tranſactions, vol. ii, page 370.

bably a principal cauſe; but it is not right to aſcribe to one cauſe only, what we find may be the reſult of many cauſes. Earthquakes, ſevere froſts, burſting waters, and ſtorms tearing up the roots of trees, have produced them in our own times; and to this variety of cauſes we muſt, at preſent, be content to aſcribe thoſe which have happened at remote periods, before we could have the opportunity of making any obſervations upon them.

But in ſurveying the ſubterranean wonders of the globe, beſide thoſe fiſſures that deſcend perpendicularly, we frequently find others that deſcend but a little way, and then ſpread themſelves often to a great extent below the ſurface. Many of theſe caverns, it muſt be confeſſed, may be the production of human art and induſtry; retreats made to protect the oppreſſed or ſhelter the robber. Such, for inſtance, are the famous labyrinths of Candia; the ſtone quarry of Maeſtricht; the ſalt mines in Poland; ſome of the catacombs in Egypt and Italy; and a great number of artificial caverns in Spain, that were made to ſerve as retreats to the Chriſtians againſt the fury of the Moors. But the greateſt number of caverns have been faſhioned by the hand of Nature only. Indeed, there is ſcarce a country in the world without its natural caverns; and, every day, many new ones are diſcovered. Of thoſe in England, Oakey-hole in Somerſetſhire, the Devil's-hole in Derbyſhire, and Penmark-hole in Glouceſterſhire, have been often deſcribed. The former lies on the ſouth ſide of Mendip-hills, about a mile from the city of Wells. To conceive a juſt idea of this, we muſt imagine a precipice of more than one hundred yards high, on the ſide of a mountain, which ſhelves away a mile above it. In this is an opening not very large, into which we enter, going along upon a rocky uneven pavement, ſometimes aſcending, and ſometimes deſcending. The roof of it, as

we advance, grows higher, and, in ſome places, is fifty feet from the floor. In ſome places, however, it is ſo low, that a man muſt ſtoop to paſs. It extends, in length, about two hundred yards; and from every part of the roof, and the floor, there are formed ſparry concretions of various figures, which by ſtrong imaginations have been likened to men, lions, and organs. At the furtheſt part of this cavern riſes a ſtream of water, well ſtored with fiſh, large enough to turn a mill, and diſcharging itſelf at the entrance.—But of all the ſubterranean caverns now known, the moſt remarkable is the Grotto of Antiparos, diſcovered in the iſland of that name, by Magni, an Italian traveller. The deſcriptions of this, by Kircher, Tournefort, and the count de Choiſeul Gouffier, are too long to be inſerted, but are highly deſerving the attention of the inquiſitive traveller, who viſits theſe ſubterraneous ſcenes for amuſement only, and the more minute obſervation of the philoſopher, ardent to purſue Nature to her moſt ſecret receſſes.

It is here natural to inquire how theſe amazing hollows of the Earth came to be formed. It ſeems evident to a philoſopher who would attend to the account of Oakey-hole, and to the deſcriptions that have been given of the other caverns I have mentioned, that their excavation has been occaſioned by ſtreams of water; which finding ſubterranean paſſages, and by degrees hollowing the beds in which they flowed, the ground above them has ſlipped down cloſer to their ſurface, leaving the upper layers of the earth or ſtone ſtill ſuſpended: the ground that ſunk upon the face of the waters forming the floor of the cavern; the ground, or rock, that kept ſuſpended, forming the roof. Indeed, there are but few of theſe caverns found without water, either within them, or near enough to point out their formation.

LXXIV. ON EXTRANEOUS FOSSILS.

There are more things in heaven and earth
Than are dreamt of in our philoſophy.

SHAKSPEARE.

THE origin of the greater part of the ſubterranean wonders is involved in ſuch impenetrable obſcurity, that the philoſopher, in his moſt profound reaſonings, as well as the poet, in his ideal excurſions, may juſtly imagine, that creation at large abounds with innumerable objects, of which the moſt laborious inquirers into nature have hitherto formed no conception. Among theſe ſubterranean wonders, that diviſion of foſſils which is denominated *extraneous*, has employed the curioſity of ſeveral of our lateſt naturaliſts.

The word Foſſil is uſed, in a general ſenſe, for any thing dug out of the Earth, as metals, ſtones, ſalts, earths, and other minerals, which are called *native* foſſils; or for any thing depoſited in the bowels of the Earth, by any extraordinary means, as earthquakes, the deluge, &c. and theſe, to which I ſhall confine my obſervations in this paper, are denominated *extraneous*. They include the ſubterranean exuviæ of marine and terreſtrial animals, and even vegetables; as ſhells, bones, teeth, trees, plants, leaves, ſtalks, &c. which are found buried, in great abundance, in various parts of the globe. Our naturaliſts have each their ſeveral ſyſtem, to account for theſe extraneous foſſils; in particular, for the ſurpriſing appearance of petrified ſea fiſhes, in places far remote from the ſea, and on the ſummits of the higheſt mountains; of ſhells in the middle of quarries of ſtone or marble; of the teeth of elephants;

of the bones of divers animals peculiar to the ſouthern climates; and of plants growing only in the eaſt, which are found foſſil in our northern and weſtern parts.

Dr. Liſter was of opinion, that theſe ſhells, &c. were real ſtones, and ſtone plants, formed after the uſual manner of other figured ſtones. But a variety of conſiderations ſoon ſatisfied the naturaliſt, that this doctrine was erroneous. Another opinion is, that the foſſil ſhells, with all other extraneous bodies found within the Earth, were buried therein at the time of the univerſal deluge. Dr. Woodward [a], in particular, purſuing and improving the theory of Dr. Burnet [b], maintained, that the whole maſs of earth, with every thing belonging to it, was ſo broken and diſſolved, at the time of the deluge, that a new earth was then formed in the boſom of the water, conſiſting of different ſtrata, or beds of terreſtrial matter, ranged over each other, uſually in the order of their ſpecific gravities. Thus plants, animals, and eſpecially fiſhes, and ſhells, not yet diſſolved among the reſt, remained mixed and blended among the mineral and foſſil matters; which preſerved them, or at leaſt aſſumed and retained their figures and impreſſions, either indentedly, or in relievo.

Camerarius, a learned German, attacked the opinion of Dr. Woodward; and the celebrated count Buffon, and the ingenious Mr. Whitehurſt, have adopted a very different theory. "The ſurface of the earth (ſays the philoſophical count) muſt have been, in the beginning, much leſs ſolid than it is at preſent; and, conſequently, the ſame cauſes, which at this day produce but very ſlight changes, muſt then, upon ſo complying a ſubſtance, have had very conſiderable effects. We have no reaſon to doubt but that it was then covered by the waters of the

[a] Woodward's Eſſay toward a Natural Hiſtory of the Earth.
[b] Burnet's Sacred Theory of the Earth.

ſea, and that thoſe waters were above the tops of the higheſt mountains, ſince, even in ſuch elevated ſituations, we find ſhells, and other marine productions, in very great abundance. It appears alſo, that the ſea continued, for a very conſiderable time, upon the face of the earth; for, as theſe layers of ſhells are found ſo very frequently at ſuch great depths, and in ſuch prodigious quantities, it ſeems impoſſible for ſuch numbers to have been ſupported all alike at one time; ſo that they muſt have been brought there by ſucceſſive depoſitions. Theſe ſhells alſo have been found in the bodies of the hardeſt rocks, where they could not have been depoſited, all at once, at the time of the deluge, or at any ſuch inſtant revolution; ſince that would be to ſuppoſe, that all the rocks in which they are found were, at that inſtant, in a ſtate of diſſolution, which it would be abſurd to aſſert. The ſea, therefore, depoſited them whereſoever they are now to be found, and that by ſlow and ſucceſſive degrees.—It will appear, alſo, that the ſea covered the whole earth, from the appearance of its layers, which lying regularly one above the other, ſeem all to reſemble the ſediment formed at different times by the ocean. Hence, by the irregular force of its waves, and its currents driving the bottom into ſandbanks, mountains muſt have been gradually formed within this univerſal covering of waters; and theſe ſucceſſively raiſing their heads above its ſurface, muſt, in time, have formed the higheſt ridges of mountains upon land, together with continents, iſlands, and low grounds, all in their turn. This opinion will receive additional weight by conſidering, that in thoſe parts of the earth where the power of the ocean is greateſt, the inequalities on the ſurface of the earth are higheſt. The power of the ocean is greateſt at the equator, where its winds and tides are moſt conſtant; and, in fact, the mountains at the equator are found to be higher than in any other

part of the world. The ſea, therefore, has produced the principal changes in our earth: rivers, volcanos, earthquakes, ſtorms, and rain, having made but ſlight alterations, and ſuch only as have affected the globe to very inconſiderable depths [a]".

Mr. Whitehurſt has given a very copious account of the various phenomenons relative to the *exuviæ* of marine animals, collected from the obſervations of Buffon, and other eminent naturaliſts, as well as from thoſe which have occurred, in the courſe of his own inſpection, in various parts of England. I ſhall extract the ſubſtance of theſe, for the information of the curious reader, and then proceed to ſtate the doctrine which he deduces from the whole.

Foſſil ſhells are found in the Alps, and, in general, in all the elevated places of Europe; in moſt of the quarries of ſtone and marble in Italy; and in the

[a] *Theorie de la Terre*, *vol.* i. *page* 111. Goldſmith, who, although his authority is not to be depended upon, has often ſome beautiful obſervations, ſpeaking of Buffon's Theory of the Earth, ſays, "A thouſand queſtions might be aſked this moſt ingenious philoſopher, which he would not find it eaſy to anſwer; but ſuch is the lot of humanity, that a ſingle Goth can in one day deſtroy the fabric which Ceſars were employed an age in erecting. We might aſk how foſſil-wood is found deeper than ſhells; which argues, that trees grew upon the places which he ſuppoſes once to have been covered by the ocean?" *Hiſtory of the Earth*, *vol.* i. *page* 36. *Edit. in* 12*mo*. And again, in page 45, he thus expreſſes himſelf: "But while there are many reaſons to perſuade us, that theſe extraneous foſſils have been depoſited by the ſea, there is one fact that will abundantly ſerve to convince us, that the earth was habitable, if not inhabited, before theſe marine ſubſtances came to be thus depoſited; for we find foſſil trees, which, no doubt, once grew upon the earth, as deep, and as much in the body of ſolid rocks, as theſe ſhells are found to be. Some of theſe fallen trees, alſo, have lain at leaſt as long, if not longer, in the earth, than the ſhells, as they have been found ſunk deep in a marly ſubſtance, compoſed of decayed ſhells, and other marine productions. M. Buffon has proved, that foſſil-ſhells could not have been depoſited in ſuch quantities all at once by the flood; and I think, from the above inſtance, it is pretty plain, that howſoever they were depoſited, the earth was covered with trees before their depoſition, and, conſequently, that the ſea could not have made a very permanent ſtay. How then ſhall we account for theſe extraordinary appearances in nature? A ſuſpenſion of all aſſent is certainly the firſt, although the moſt mortifying conduct," &c.

ſtones of which the moſt ancient edifices of the Romans were conſtructed. In Swiſſerland, Aſia, and Africa, petrified fiſh have been obſerved in many places; for inſtance, on the mountains of Caſtravan, there is a bed of white laminated ſtone: and each *lamina* contains a great number and diverſity of fiſhes; for the moſt part very flat, and extremely compreſſed, in the mannner of foſſil fern; yet ſo well preſerved, that the moſt minute marks of their fins and ſcales are diſtinguiſhable, and every other part by which one ſpecies of fiſh is known from another. The teeth of ſharks, and of other fiſhes, are found in the jaws, poliſhed and worn ſmooth at the extremities, and which, conſequently, muſt have been made uſe of, during the life of the animal: and, in the ſhells, the very pearls are found, which the living animals of the ſame kind produce.

It is well known, that the *purpura* and *pholades* have a long pointed proboſcis, which ſerves them as a kind of gimblet or drill, to pierce the ſhells of living fiſh, on whoſe fleſh they feed. Now, ſhells thus pierced are found in the earth, which is another inconteſtable proof, that they heretofore incloſed living fiſh, and that theſe fiſh inhabited places where the *purpura* and *pholades* preyed upon them.

In the Alps and Pyrenean mountains ſhells are found under beds of ſtone, a hundred, and even a thouſand feet below the ſurface of the earth; and not merely thoſe which are teſtaceous, but the relicks of the cruſtaceous fiſhes alſo, and even all marine productions. Mr. Whitehurſt, moreover, is of opinion, that in the generality of marbles there is ſo great a quantity of marine productions, that they appear to ſurpaſs in bulk the matter by which they are united.

Among the many inſtances of the multiplicity of oyſters, there are few more extraordinary than that immenſe bed, of which M. Reaumur gives an ac-

count, which contains 130,630,000 cubit fathoms. This vaſt maſs of marine bodies is in Touraine in France, above thirty-ſix leagues from the ſea. Some of theſe ſhells are found ſo entire, that their different ſpecies are very diſtinguiſhable. Some of the ſame ſpecies have been recently found on the coaſt of Poitou, and others are known to be natives of more diſtant parts of the world. Among them are likewiſe blended ſome fragments of the more ſtony kinds of ſea productions, ſuch as *madripores*, *fungi marini*, &c. The canton of Touraine contains full nine ſquare leagues in ſurface, and, wherever it is dug, furniſhes theſe fragments of ſhells.

Mr. Whitehurſt obſerves, that we ſhall be leſs aſtoniſhed at this very conſiderable quantity of ſhells, when we conſider the vaſt increaſe of ſhellfiſh. It is not uncommon to take away a bed of theſe ſhellfiſh, ſeveral fathoms in thickneſs; and although the places where they are fiſhed for appear to be entirely exhauſted, yet, in the enſuing year, as many will be found in all theſe places as before.

Hardel Cliff, in Hampſhire, contains a great variety of turbinated and bivalve ſhells, which ſtill retain the native matter and colour of marine ſhells. Many of theſe are natives of very diſtant regions; and others of them are not known to exiſt in a living ſtate. In ſome parts of Suffolk, they are ſo numerous, that they are dug up for manure, and produce excellent crops.

Within ten yards of the ſummit of Naphat, a remarkable mountain in Ireland, elevated ſeveral hundred fathoms above the level of the ſea, are many vaſt beds of marine ſhells of various kinds, as whelks, muſcles, cockles, &c. In Derbyſhire and Staffordſhire, Mr. Whitehurſt frequently obſerved, with aſtoniſhment, enormous maſſes of limeſtone compoſed almoſt entirely of foſſil ſhells, or other marine relicks, diffuſed throughout the ſolid ſubſtance of

the ſtrata. The iſle of Sheepy, in Kent, contains not only the teeth of ſharks, and the bones of fiſh, but ſuch a great variety of foſſil bodies belonging both to the animal and vegetable kingdoms, as evidently ſhow it to be an aſſemblage of adventitious matter. In a word, the remains of marine animals imbedded in the ſolid ſubſtance of ſtone, chalk, and clay, and in ſand, gravel, &c. in all parts of the known world, are ſo extremely numerous, that it is quite unneceſſary to add any more inſtances of the kind [a].

Mr. Whitehurſt, in collecting together theſe, and many other curious facts, relative to foſſil bodies, does not appear to have had any intention to point out the faults of other ſyſtems, but to avail himſelf of ſuch parts of them as were applicable to his own deſign; namely, "to trace appearances in nature from cauſes truly exiſtent, and to inquire after thoſe laws by which the Creator choſe to form the world, not thoſe by which he might have formed it, had he ſo pleaſed".—In conſequence of this deſign, having given a very copious and ſcientific account of the general phenomenons of foſſil bodies, he has deduced from them the following inferences.

Firſt, The great analogy in the figure, colour, and conſiſtence of foſſil bodies, to the ſhells, bones, and teeth of living fiſh, together with a gradual change in their component parts, from a teſtaceous, to a ſtony metallic ſubſtance, evidently ſhows, that all ſuch foſſil bodies were originally productions of the ſea.

Secondly, Their being found in all parts of the world, even imbedded in the higheſt mountains, vallies, and deep receſſes of the earth, remote from the ſea, evidently ſhows that the ſea prevailed univer-

[a] For a great variety of particulars on this intereſting ſubject, the curious reader is referred to Mr. Whitehurſt's Inquiry into the Original State and Formation of the Earth, chap. vii.

ſally over the earth [a]; and, conſequently, that theſe marine animals were created prior to the primitive iſlands [b], and likewiſe prior to terreſtrial animals, agreeably to the ſcripture account of the creation.

Thirdly, And ſince they are found at various depths in the earth, even to that of ſeveral thouſand feet, and in different ſtates of decay, and variouſly impregnated with ſtony or metallic matter, and even changed into the ſubſtance of the ſtone in which they are imbedded; it evidently appears, that the ſtrata were originally in a ſtate of fluidity, and that they were thus entombed and deprived of life, in ſucceſſive periods of time.

Fourthly, The beds of foſſil ſhells which conſiſt of one ſpecies only, and are not native of the climate where found, but of very diſtant regions of the earth, evidently ſhow that they were generated, and have lived and died, in the very beds where found, and could not have been removed from their native climate by a flood, or floods of water, with ſo much order, as to form beds conſiſting of only one ſelect ſpecies; and, therefore, all ſuch beds muſt have been originally the bottom of the ocean.

Such are the inferences which Mr. Whitehurſt has deduced from the intereſting facts he has collected; which tend to corroborate, he obſerves, the ſeveral reſults ariſing from the former parts of his Inquiry into the Original State and Formation of the Earth: namely, that the earth was originally a fluid chaotic maſs, totally unfit for animal or vegetable life: that it was progreſſively formed into a habitable world: that marine animals were created prior to the primitive iſlands, and conſequently prior to terreſtrial animals: that they were entombed in the bowels of the earth, in ſucceſſive periods of time, and before dry land appeared.

[a] See Inquiry, ch. v. [b] Ib. ch. vi.

LXXV. ON THE MINERAL PRODUCTIONS OF THE EARTH.

Æs atque aurum, ferrumque repertum eſt,
Et ſimul argenti pondus plumbique— LUCRET.

Then braſs, and gold, and iron ore, were found,
And pond'rous lead and ſilver preſs'd the ground.

IN my laſt two papers, I have conducted my readers into the interior regions of our globe: I have treated of its wonderful natural fiſſures and caverns, the diſpoſition of the different kinds of earths, and the nature and origin of that part of foſſil productions, which we denominate *extraneous.* I have been hitherto accompanied by the philoſopher, not the poet: in treating, however, of mines, and their productions, which I have already noticed as *native* foſſils, I find more than one poetical invitation:

Through dark retreats purſue the winding ore,
Search Nature's depths, and view her boundleſs ſtore;
The ſecret cauſe in tuneful numbers ſing,
How metals firſt were fram'd, and whence they ſpring:
Whether the active ſun, with chymic flames,
Through porous earth tranſmits his genial beams;
With heat impregnating the womb of night,
The offspring ſhines with its paternal light:—
Or whether, urg'd by ſubterraneous flames,
The earth ferments, and flows in liquid ſtreams;
Purg'd from their droſs, the nobler parts refine,
Receive new forms, and with freſh beauties ſhine:—
Or whether by creation firſt they ſprung,
When yet unpois'd the world's great fabric hung:
Metals the baſis of the earth were made,
The bars on which its fix'd foundation 's laid:
All ſecond cauſes they diſdain to own,
And from th' Almighty's fiat ſprung alone. YALDEN.

And now the regions deep explore,
Where metals ripen in vaſt cakes of ore.
Here, ſullen to the ſight, at large is ſpread
The dull unwieldy maſs of lumpiſh lead.
There, glimm'ring in their dawning beds, are ſeen
The light aſpiring ſeeds of ſprightly tin.
The copper ſparkles next in ruddy ſtreaks;
And in the gloom betrays its gloomy ſtreaks.
The ſilver then, with bright and burniſh'd grace,
Youth and a blooming luſtre in its face,
To th' arms of thoſe more yielding metals flies,
And in the folds of their embraces lies. GARTH.

In treating this ſubject philoſophically, it is requiſite firſt to mention mines, thoſe artificial excavations, in which metals, minerals, or even precious ſtones, are dug up. Theſe mines obtain various denominations, becauſe the matter, or ſubſtances, dug out of them, is various. Thus, there are gold-mines, ſilver-mines, copper-mines, lead-mines, tin-mines, iron-mines, diamond-mines, mines of antimony, of alum, &c.

The richeſt and moſt celebrated gold and ſilver-mines are thoſe of Peru and Chili, in South America. Iron mines are more abundant in Europe than elſewhere. Copper-mines are chiefly found in Sweden, Denmark, and England; and lead and tin mines in England; the latter, more particularly in the county of Cornwall. Quickſilver-mines abound principally in Hungary, Spain, Friuli in the Venetian territories, and Peru; diamond-mines, in the Eaſt Indies, and in the Braſils; and ſalt-mines in Poland.

The word *mineral* is ſometimes uſed in the general for *foſſil*, and is applied to any ſubſtance, ſimple or compound, dug out of a ſubterraneous place, or *mine*; from which it takes the denomination. In this ſenſe, metals, ſulphurs, foſſil ſalts, ſemi-metals, &c. are minerals. On this principle, minerals

are divided into two classes; the one *fusible*, and *malleable*, that is, which melt with fire, and stretch on the anvil: which are what we properly call *metals*. The other class want these two properties, and are what in the strictest sense we call *minerals*.

According to some, minerals may be divided into *simple* and *compound*. To the first belong stones; salts, as alum, nitre, &c. inflammable minerals, as sulphur and bitumen; and metals, as gold, &c. Other more accurate writers restrain the word mineral to what we otherwise call *semimetals*, as antimony, cobalt, &c.

The word mineral, in this sense, may be defined a compound fossil, in which something is discovered, in all respects like metal, only that it is not malleable; joined or compounded with some other fossil, as salt, sulphur, stone, or earth. Such are antimony, cinnabar, bismuth, calaminaris, vitriol, pyrites, marcasites, cobalt, oker, the magnet, lapis hæmatites, and armenus.

Of the origin of minerals there are various opinions. Some philosophers attribute the formation of them to the action of the sun without: some, to the influence of the central fire within; and some think, that cold is the productive cause, by uniting, condensing, and congealing certain juices of the earth.

To the first two opinions Dr. Yalden alludes in the lines quoted above; and Thomson, in his beautiful Hymn to the Sun, extends the penetrating influence of that luminary, not to the formation of metals only, but to the production also of the precious stones:

Nor to the surface of enliven'd earth,
Graceful with hills and dales, and leafy woods,
Her liberal tresses, is thy force confin'd:
But to the bowel'd cavern darting deep,
The mineral kinds confess thy mighty power.

Effulgent, hence the veiny marble ſhines;
Hence Labour draws his tools; hence burniſh'd War
Gleams on the day; the nobler works of Peace
Hence bleſs mankind, and generous Commerce binds
The round of nations in a golden chain.
Th' unfruitful rock itſelf, impregn'd by thee,
In dark retirement forms the lucid ſtone.
The lively diamond drinks thy pureſt rays,
Collected light, compact; that, poliſh'd bright,
And all its native luſtre let abroad,
Dares, as it ſparkles on the fair-one's breaſt,
With vain ambition emulate her eyes.
At thee the ruby lights its deepening glow,
And with a waving radiance inward flames.
From thee the ſaphire, ſolid ether, takes
Its hue cerulian; and, of evening tinct,
The purple-ſtreaming amethyſt is thine.
With thy own ſmile the yellow topaz burns;
Nor deeper verdure dies the robe of Spring,
When firſt ſhe gives it to the ſouthern gale,
Than the green emerald ſhows. But, all combin'd,
Thick through the whitening opal play thy beams;
Or, flying ſeveral from its ſurface, form
A trembling variance of revolving hues,
As the ſite varies in the gazer's hand.

Deſcartes was of opinion that metals were formed from the beginning of the world, and were ranged, by the laws of gravity, about the centre. Theſe he ſuppoſes to have been corroded, in proceſs of time, by the acid ſalts, &c. and abundance of their parts carried up along with theſe ſalts by the ſubterranean heat, and depoſited in various parts of the earth.— M. Tournefort ſuppoſes ſeeds of minerals, as well as of animals and vegetables. According to this celebrated botaniſt, every thing, ſtones not excepted, comes from eggs; and the moſt prodigious rocks, he thinks, were originally no more than grains of ſand. The alchymiſts maintain, that metals proceed from a certain *primum ens*, or firſt ſeed of metals,

which, they ſay, is a kind of moiſt vapour, or gas, that changes the earth or juice it meets with in a vein into a mineral body or ſubſtance, and thence converts the minerals into ores or metals, by a continued fermentation or elaboration in the mines, cauſed by the *archeus*, or heat that acts in the veins, as it proceeds from the centre of the earth. But this doctrine of mineral fermentation is poſitively denied by the great Boerhaave, who, in his Hiſtory of Fermentation, aſſerts, that it belongs to the vegetable kingdom only. Others maintain, that all metals and minerals were originally created in the very ſame ſtate and nature in which they are ever found, without undergoing any kind of alteration. The moſt common opinion, among the miners of Cornwall, is, that crude immature minerals nouriſh and feed the ores with which they are intermixed in the mines; and that the minerals themſelves will, in proceſs of time, be converted into ores, productive of thoſe metals to which they have the neareſt affinity, and with which they have the greateſt intercourſe.

M. Geoffrey and others contend, that metals, &c. may be the reſult of a mixture of certain matters, which had nothing metallic in them. Thus, in the aſhes of all vegetables, we find a ferruginous matter, which the loadſtone attracts; and yet it can hardly be ſaid, that iron exiſted in the plants. We ſee no ſigns of iron in clay, in whatever manner it may be worked; and yet, let linſeed-oil be added to it, and by fire iron may be procured. The ſame may be ſaid of many other ſubſtances. It is probable, therefore, that metals may be formed by a combination of different ingredients; much like ſulphur, which is known to be made by adding an inflammable principle to a vitriolic ſalt. Our globe may abound every where with thoſe matters, which are continually circulating through its pores and canals,

and which, meeting with an earth homogenous to them, fix thereto, and commence minerals.

Mr. Price, in his Mineralogia Cornubiensis, supposes it most reasonable to conclude, that metals were made and planted in veins, at, or very soon after the creation of the world; but that they are subject to a degree of fluctuation in common with all other matter, approaching to, or receding from, their ultimate degree of perfection, either quicker or slower, as they are of greater or less solid and durable frame and constitution. He supposes, that in every metal there is a peculiar magnetism, and an approximation of particles, *sui generis*, by which its component principles are drawn and united together; particularly the matters left by the decomposition of the waters passing through the contiguous earths or *strata*, and deposited in their proper *nidus* or receptacle; till by the accretion of more or less of its homogenous particles, it may be denominated either rich or barren.

The minerals, metals, and stones, lie in beds; and have done so ever since the flood, if not from the creation. But it is highly probable that they have a faculty of growing in their respective beds, and that, as the beds are robbed and emptied by miners, so, after a while, they recruit again. Thus vitriol, Mr. Boyle thinks, may grow by the help of the air, and that alum does the same. "We are assured (says this excellent philosopher) by the experienced Agricola, that the earth or ore of alum, being robbed of its salts, will, in tract of time, recover them again, by being exposed to the air".

There is great reason to believe that metals likewise grow, from what has been alledged by Mr. Boyle, in his observations about the growth of metals, and particularly as to the growth of iron. To the instances he brings from Pliny, Fallopius,

Cesalpinus, and others, we may add, that in the forest of Dean, in Gloucestershire, the best iron, and in the greatest quantities, is found in the old cinders, which they melt over again. This is imputed by some to the negligence of the former melters in not exhausting the ore; and Dr. Derham thinks it rather owing to the new impregnations of the old ore, or cinders, from the air, than to any seminal principle in the ore itself. There are some other facts however, which it is proper to mention here, although they are not all equally well attested. In some mines, it is said, the metals are found, at their first opening, very crude and imperfect; but which, nevertheless, in process of time, grow ripe and rich. Alonso Barba relates, that, in Potosi, stones have frequently been thrown aside, as not containing any thing considerable of metal, and yet have been found exceedingly full of it, many years afterward. Cesalpinus assures us, that earths, which before yielded no metal at all, sometimes became very fertile veins; and, in an island of the Tyrrhene sea, after the iron mines have been exhausted, they stop them about ten years; at the expiration of which, it is said, they are found as rich as before.

This subject would lead me beyond my limits, I shall therefore refer my readers to the English Dictionary of Chemistry, for many ingenious remarks on the formation of minerals; and shall conclude this paper with some general observations on the mineral kingdom.

It is utterly impossible for a being, endued, like man, with such a limited understanding, to embrace at one view, the universal reign of Nature, and to comprehend, in their entire extent, the wonderful properties of every object. We must be content to acquire an imperfect knowledge of Nature, by examining, from time to time, some isolated objects, some particular beauties, but with as much

attention as poſſible to a ſucceſſive order and arrangement, without which our ſtudies would be deſultory and uninſtructive. Let us confine our attention, at preſent, to ſome of the moſt ſtriking phenomenons of the mineral kingdom.

Among ſtones there is not one that deſerves more attention than the magnet, but of this I have already treated in a former paper [a].

Properties equally wonderful are to be found in quickſilver. It yields to every form we may chooſe to give it; but it never fails to reſume that which is natural to it. Expoſed to the fire, it aſcends in fume. By a chymical proceſs, it may be converted into a hard and tranſparent cryſtal; but it may be reduced again to its original fluidity. Its uſes in medicine, in the barometer, in looking-glaſſes, in gilding, &c. are well known. But a minute account of all its properties would fill a volume.

Gold is the principal and moſt valuable of all the metals, not only on account of its ſcarcity, but of its many admirable properties. Of all bodies it is the moſt tenacious and unalterable; inſomuch that it will bear the action of the moſt violent fire for two months, without any ſenſible diminution of its weight. Its parts are ſo ſubtile, that a grain of leaf gold can cover fifty ſquare inches; ſo that upon the two ſurfaces, on a ſlight inſpection, may be diſtinguiſhed four millions of parts. And its ductility is ſuch, that from a ſingle grain may be drawn a wire five hundred feet long.

The wonderful form of common ſalt, the precious ſtones, the ſingular ſhapes of the ores, or metals in their mineral ſtate, the aſtoniſhing particulars we have already noticed of extraneous foſſils, and a variety of inexhauſtible objects of inquiry in the mineral kingdom, ſeem formed, with the other won-

[a] No. LII, On the Magnetiſm and the Mariner's Compaſs.

ders of creation, to excite our curiosity. And it must be confessed, that there is not an employment of the mind, productive of greater delight, of more solid satisfaction, nor of a greater variety of enjoyment, than an attentive contemplation of the works of Nature. Were we to live, for ages, in this world, and to employ every day, in studying the phenomenons and singularities of the mineral kingdom only, we should still find innumerable things which we could not explain, which would excite more and more our curiosity, and yet continue inscrutible by our finite capacities. Let us employ then, at least, since the duration of our lives scarce extends beyond half a century, let us well employ the short time that is granted to us here, and devote as much of it as the necessary duties of life will permit, to the study of Nature; and, by thus enriching our minds, treasure up the most innocent and the most inexhaustible stores of knowledge and pleasure. The exquisite delight which such studies afford, will be heightened more and more, in proportion as we meditate on the ends which the Creator has proposed in his works; for the wonders of Nature are more admirable and more sublime than all the productions of human art. These are not always compatible with our welfare; and, so far from rendering us either wiser or better, they are often the mere objects of uninstructive admiration. But all the works of Nature, even the most singular and inexplicable, have for their object the felicity of the whole creation. They exist, not merely to be contemplated as objects of sight, but to be enjoyed; and all, without exception, proclaim unspeakable goodness, as well as unsearchable wisdom and unbounded power.

Oh, Nature, all-sufficient, over all!
Enrich me with the knowledge of thy works!

Snatch me to heaven; thy rolling wonders there,
World beyond world in infinite extent,
Profusely scatter'd o'er the blue immense,
Show me; their motions, periods, and their laws,
Give me to scan; through the disclosing deep
Light my blind way; *the mineral strata there*;
Thrust, blooming, thence the vegetable world;
O'er that the rising system, more complex,
Of animals; and higher still, the mind,
The varied scene of quick-compounded thought,
And where the mixing passions endless shift;
These ever open to my ravish'd eye;
A search the flight of time can ne'er exhaust!

THOMSON.

LXXVI. ON MOUNTAINS.

So pleas'd at firſt the towering Alps we try,
Mount o'er the vales, and ſeem to tread the ſky;
Th' eternal ſnows appear already paſt,
And the firſt clouds and mountains ſeem the laſt:
But, thoſe attain'd, we tremble to ſurvey
The growing labours of the lengthen'd way,
Th' increaſing proſpect tires our wandering eyes,
Hills peep o'er hills, and Alps on Alps ariſe. POPE.

EMERGING from the vaſt abyſſes of the earth, we proceed once more to contemplate its external appearance, in all its picturesque and pleaſing, or magnificent and tremendous varieties. Mountains are the firſt objects that ſtrike the imagination, and excite our curioſity, in the wonderful proſpect before us. There is nothing in all nature, perhaps, that can impreſs a ſpectator, unaccuſtomed to theſe views, with ſuch ideas of ſolemnity and awe, as the ſtupendous piles of Nature, before which the proudeſt monuments of human art dwindle into minuteneſs and inſignificance.

In countries, where there is nothing but plains, the ſmalleſt elevations are apt to excite our wonder. In Holland, the whole ſurface of which is flat, a little ridge of hills is ſhown, near the ſeaſide, which the great Boerhaave generally mentioned to his pupils as mountains of no ſmall conſequence. But what would be the ſenſations of ſuch an audience, could they be preſented, at once, with a view of the heights and precipices of the Alps or of the Andes! Even in this iſland, we have no adequate ideas of a mountain proſpect. Our hills are generally ſloping from the plain, and clothed to their very ſummits with verdure. It is ſcarcely poſſible, therefore, to

exalt our conceptions to thoſe immenſe piles, whoſe tops faintly appear behind intervening clouds, ſharp and precipitate, and ſoar to heights, which human avarice or curioſity have never been able to aſcend:

Rocks rich in gems, and mountains big with mines,
That on the high equator ridgy riſe,
Whence many a burſting ſtream auriferous plays.

THOMSON.

The *origin* of mountains is a ſubject which has given riſe to many philoſophical diſquiſitions. Burnet, Whiſton, Woodward, and Buffon have endeavoured to account for them in their reſpective theories of the earth. Mr. Ray, M. le Cat, and M. Pallas have likewiſe their ſyſtems. But the moſt ſatisfactory account, in my opinion, is that given by Mr. Whitehurſt, in his Inquiry into the Original State and Formation of the Earth. According to this excellent philoſopher (who, inſtead of ſpeculative inquiries in the cloſet, deſcended into the bowels of the earth, in queſt of *data*, from which we might draw juſt or probable inferences) the antediluvian world was very different from that which we contemplate at preſent. It conſiſted only of ſmall iſlands gradually riſing from the deep; or of ſmooth, even, and uniform elevations: whereas the world on which we tread at preſent conſiſts of immenſe continents and mountains, of ſteep or impending ſhores, craggy rocks, and extenſive vallies and caverns. Our marine *exuviæ* formerly lay at the bottom of the ocean of the primitive world; whereas many of them are now ſituate near the tops of thoſe immenſe mountains, the Alps and the Andes, and at great diſtances from the ſea. To account for ſo great a revolution, Mr. Whitehurſt has collected many inſtances from hiſtory of ſtupendous changes that have been produced on the ſurface and in the bowels of the earth. He enumerates ſome of the more ſtriking inſtances

of the rising of islands, such as Santorini, Hiera, &c. from the bottom of the sea, attended with *eruptions of fire*. He mentions several islands and mountains having volcanic appearances, and which may likewise be supposed to owe their origin to the same cause, in times anterior to all history. Such are Iceland, Fyal, &c. in the northern sea; St Helena and Ascension islands, between Africa and Brazil; Easter or Davis' island, Otaheite, &c. in the Southern Ocean; several of the Moluccas, in the Indian Sea; Madeira, several of the Azores and the Antilles, &c. in the Atlantic Ocean; the Lipari islands, Ischai, &c. in the Mediterranean. After collecting many instances of mountains formed, and large districts of land swallowed up, shattered, and rent asunder, by earthquakes, and particularly by volcanos, he observes, that we may, by analogy, be justified in inferring, that all similar appearances may have been the effects of the same cause; and though vestiges of volcanos are not every where visible, the earth exhibits indications of their having existed in so many different regions, that there is reason to suppose that subterraneous fire must, at different times, have existed universally in its bowels. He then proceeds to show, that this cause, acting on a larger scale, produced, at the same time, the immense continent and mountains in the present globe and the universal deluge.

When Mr. Whitehurst ascribes these great phenomenons to *fire*, it must be understood, that he means, in general, the united actions of fire and water; or the expansive power of the latter when converted into *steam*, or an elastic vapour, by means of heat; a force which is, indeed, enormous, and which has been lately calculated, from actual experiments, to exceed even that of gunpowder, in the proportion of 14c to 5.

Fire, acting alone at first, and with an intensity

gradually increaſing on the ſuperincumbent *ſtrata*, Mr. Whitehurſt ſuppoſes to have gradually diſtended and elevated thoſe parts moſt, on which the antediluvian ocean reſted, as the primitive iſlands, by their additional weight of ſolid and heavy matter, oppoſed a greater reſiſtance. The waters thus raiſed would naturally flow toward the now leſs elevated ſolid parts, or antediluvian iſlands; and would finally cover them, ſo as to produce a *univerſal deluge.*

The expanſion cauſed by fire increaſing, till its force became ſuperior to the gravity, and coheſion, or tenacity, of the incumbent *ſtrata*; the latter would at length burſt, and through the fiſſures a communication would be opened between the water and the ignited melted matter below. By the ſteam thus ſuddenly generated, exploſions would enſue, which muſt deſtroy the uniformity of the globe, ſhatter it into fragments, produce immenſe mountains, and extenſive and deep ſubterraneous caverns; into which laſt the waters would afterward deſcend, and leave the various continents, mountains, &c. in nearly the ſame ſtate in which we now view them; and containing the ſame ſhells, and other marine *exuviæ* which they brought up with them from the bottom of the ſea.

"The terraqueous globe (ſays Mr. Whitehurſt) being thus burſt into millions of fragments, and from a cauſe apparently ſeated nearer to its centre than its ſurface, muſt certainly have been thrown into ſtrange heaps of ruins: for the fragments of the *ſtrata*, thus blown up, could not poſſibly fall together again into their primitive order and regularity: therefore an infinite number of ſubterraneous caverns muſt have enſued at the diſtance of many miles, or many hundreds of miles below the bottom of the antediluvian ſea.

"Now it is eaſy to conceive, when a body of ſuch an immenſe magnitude as the earth, which is

nearly 8000 miles in diameter, was thus reduced to a heap of ſruins, that its incumbent water would immediately deſcend into the cavernous parts thereof; and by thus approaching ſo much nearer toward the centre, than in its antediluvian ſtate, much of the terreſtrial ſurface became naked and expoſed, with all its horrid gulfs, craggy rocks, mountains, and other diſorderly appearances.

"Thus, the primitive ſtate of the earth ſeems to have been totally metamorphoſed at the firſt convulſion of Nature, at the time of the deluge; its *ſtrata* broken, and thrown into every poſſible degree of confuſion and diſorder. Hence, thoſe mighty eminences the Alps, the Andes, the Pyrenean, and all other chains of mountains, were brought from beneath the great deep. Hence, the ſea retired from thoſe vaſt tracts of land, the continents; became fathomleſs and environed with craggy rocks, cliffs, and impending ſhores; and its bottom ſpread with mountains and vallies like the land.

"It is further to be obſerved of the horrid effects of this convulſion; namely, that as the primitive iſlands were more ponderous and leſs elevated than the bottom of the ſea; may we not thence infer, that the former more immediately ſubſided into the ocean of melted matter than the latter; and therefore became the bottom of the poſtdiluvian ſea: and the bottom of the antediluvian ſea being more elevated, was converted into the poſtdiluvian mountains, continents, &c. Such were apparently the conſequences ariſing from the convulſion of nature; and this conjecture is remarkably confirmed by the vaſt number of foſſil ſhells, and other marine *exuviæ*, found imbedded near the tops of mountains, and the interior parts of continents, remote from the ſea, in all parts of the world hitherto explored [a]".—But there are

[a] See No. LXXIV, On Extraneous Foſsils.

many particulars, neceſſary for a more perfect elucidation of this intereſting ſubject, for which I muſt refer to the excellent work itſelf[a].

In this manner, and by employing a cauſe that appears adequate to the effect, and which is known, even at this time, partially to exiſt, Mr. Whitehurſt very rationally accounts for the ſingular appearances which the preſent earth exhibits on and beneath its ſurface, for the univerſal deluge, and its ceſſation; and he does this without having recourſe to comets, a ſudden alteration of the earth's centre of gravity, and other violent and purely gratuitous aſſumptions.

It is ſcarcely neceſſary to obſerve, that, with reſpect to height, there are many ſizes of mountains, from the gently-riſing upland to the tall craggy precipice. The appearances are, in general, different, in thoſe of different magnitudes. The firſt are clothed with verdure to their very tops, and ſeem to aſcend merely to improve our proſpects, or to ſupply us with a purer air. but the lofty mountains of the other claſs have a very different aſpect. At a diſtance, their tops are ſeen, in wavy ridges, of the very colour of the clouds, and to be diſtinguiſhed from them by their figure only, which, as juſt obſerved, reſembles the billows of the ſea[b]. As we approach, the mountain aſſumes a deeper colour: it gathers upon the ſky, and ſeems to hide half the horizon behind it. Its ſummits alſo are become more diſtinct, and appear with a broken and perpendicular line. What at firſt ſeemed a ſingle hill, is now found to be a chain of continued mountains, whoſe tops running along its ridges, are emboſomed in each other; ſo that the curvatures of one are fitted to the prominences of the oppoſite ſide, and form a winding valley between, often of ſeveral miles in

a Whitehurſt's Inquiry, chap. XII.

b Lettres Philoſophiques ſur la Formation des Montagnes, &c. page

extent; and all the way continuing nearly of the ſame breadth.

Nothing can be finer, or more exact, than the deſcription in my motto, of a traveller ſtraining up the Alps. Every mountain he comes to he thinks will be the laſt: he finds, however, an unexpected hill riſe before him; and that being ſcaled, he beholds the higheſt ſummit almoſt at as great a diſtance as before. Upon quitting the plain, he left, perhaps, a green and fertile ſoil, and a warm and pleaſing climate. As he aſcends, the ground aſſumes a more ruſſet colour; the graſs becomes more moſſy, and the weather more moderate. Still, as he aſcends, the weather becomes colder, and the earth more barren. In this dreary paſſage, he is often entertained with a little valley of ſurpriſing verdure, cauſed by the reflected heat of the ſun collected into a narrow ſpot on the ſurrounding heights. But it much more frequently happens that he ſees only frightful precipices beneath, and lakes of amazing depth, whence rivers are formed, and fountains derive their origin. On thoſe places next the higheſt ſummits, vegetation is ſcarcely carried on: here and there, a few plants of the moſt hardy kind may be found. The air is intolerably cold; either continually refrigerated by froſts, or diſturbed by tempeſts. All the ground here wears an eternal covering of ice, and ſnows that ſeem to be conſtantly accumulating. Emerging from this war of the elements, the traveller aſcends into a purer and more ſerene region, where vegetation has wholly ceaſed; where the precipices, compoſed entirely of rocks, riſe perpendicularly above him; while he views beneath him all the combat of the elements; clouds at his feet; and thunders darting up from their boſom below [a]. A thouſand meteors, which are never ſeen

[a] Ulloa's Voyage to the South Sea, vol. i.

on the plain, preſent themſelves. Circular rainbows [a]; mock-ſuns; the ſhadow of the mountain projected upon the body of the air [b]; and the traveller's own image, reflected, as in a looking-glaſs, upon the oppoſite cloud [c].

Such, in general, are the wonders that preſent themſelves to the traveller, in his journey over the Alps, but more particularly in the Andes. But we muſt not ſuppoſe that this picture exhibits an invariable likeneſs of theſe ſtupendous heights. Indeed, nothing can be more capricious and irregular than the forms of many of them. The tops of ſome run in ridges for a conſiderable length, without interruption: in others, the line ſeems indented by great vallies to an amazing depth. Sometimes, one ſolitary mountain riſes from the boſom of the plain; and ſometimes extenſive plains, and even provinces, as thoſe of Savoy and Quito, are found emboſomed near the tops of mountains.—But I muſt poſtpone to my next paper, the further conſideration of this ſubject, of which many intereſting particulars are yet to be noticed.

[a] Ulloa's Voyage to the South Sea, vol. i.
[b] Philoſ. Tranſ. vol. v. page 152.
[c] Ulloa, vol. i.

LXXVII. FURTHER OBSERVATIONS ON MOUNTAINS.

Again, where Alpine ſolitudes aſcend,
I ſit me down a penſive hour to ſpend;
And, placed on high above the ſtorm's career,
Look downward where a hundred realms appear;
Lakes, foreſts, cities, plains extending wide,
The pomp of kings, the ſhepherd's humbler pride.

GOLDSMITH.

I CONCLUDED my former paper with a ſlight ſketch of the variety of picturesque appearances which mountains, in general, exhibit: and theſe we ſeldom find forgotten, either in the delineations of the pencil, or in poetical deſcription.

Sometimes the pencil, in cool airy halls,
Bade the gay bloom of vernal landſcapes riſe,
Or Autumn's varied ſhades imbrown the walls:
Now the black tempeſt ſtrikes th' aſtoniſh'd eyes,
Now down the ſteep the flaſhing torrent flies;
The trembling ſun now plays o'er ocean blue,
And now rude mountains frown amid the ſkies;
Whate'er Lorraine light-touch'd with ſoft'ning hue,
Or ſavage Roſa daſh'd, or learned Pouſſin drew.

THOMSON.

If we compare the heights of different mountains, we ſhall find that the greateſt and higheſt are found under the line. It is thought by ſome, that the rapidity of the earth's motion, together with the greatneſs of the tides, in thoſe parts, may have thrown up theſe ſtupendous maſſes of earth. But, to whatever cauſe it may be attributed, it is a remarkable fact, that the inequalities of the earth's ſurface are the greateſt at the equator. The earth, indeed, is very craggy and uneven near the poles; but the heights of the mountains there are very inconſidera-

ble. On the contrary, at the equator, where Nature ſeems to ſport in the amazing ſize of her productions, the plains are extenſive, and the mountains remarkably lofty. Some of them are known to riſe three miles in height above the level of the ocean.

To enumerate the moſt remarkable of theſe, according to their ſize, I ſhall begin with the Andes, a prodigious chain of mountains, extending almoſt the whole length of South America, parallel with the two oceans, and terminating at the ſtraits of Magellan. Of theſe mountains we have an excellent deſcription by don Juan de Ulloa, who, by command of the king of Spain, went to Peru, in company with the French academicians, to meaſure a degree of the meridian. His account of his journey up theſe mountains is ſo curious, that I cannot forbear to give an extract from it.

After many days ſailing up the river Guayaquil, he arrived at Caracol, a town ſituate at the foot of the Andes. Nothing can exceed the inconveniencies he had experienced in this voyage, from the flies and moſchitos. "We were the whole day (ſays he) in continual motion, to keep them off; but, at night, our torments were exceſſive. Our gloves, indeed, were ſome defence to our hands; but our faces were entirely expoſed; nor were our clothes a ſufficient defence for the reſt of our bodies; for the ſtings of theſe inſects, penetrating through the cloth, cauſed a very painful itching. One night, in coming to anchor near a large and handſome houſe that was uninhabited, we were no ſooner ſeated in it, than we were attacked, on all ſides, by ſwarms of moſchitos, ſo that it was impoſſible to have one moment's quiet. They who had covered themſelves with clothes made for this purpoſe, found not the ſmalleſt defence; wherefore, hoping to find ſome relief in the open fields, they ventured out, although in

danger of ſuffering, in a more terrible manner, from the ſerpents. But both places were equally obnoxious. On quitting this inhoſpitable retreat, we took up our quarters, the next night, in a houſe that was inhabited; the maſter of which being informed of the terrible manner we had paſſed the preceding night, told us gravely that the houſe we ſo greatly complained of, had been forſaken, on account of its being the purgatory of a ſoul. But we had more reaſon to believe that it was quitted on account of its being the purgatory of the body. After having journied, upward of three days, through boggy roads, in which the mules ſunk to their bellies at every ſtep, we began, at length, to perceive an alteration in the climate; and, after having been long accuſtomed to heat, we now felt it grown very ſenſibly colder.

"It is remarkable, that at Taraguagua we often ſee inſtances of the effects of two oppoſite temperatures, in two perſons happening to meet; one of them leaving the plains below, and the other deſcending from the mountain. The former thinks the cold ſo ſevere, that he wraps himſelf up in all the garments he can procure; while the latter finds the heat ſo great, that he is ſcarcely able to bear any clothes whatever. The one thinks the water ſo cold, that he avoids being ſprinkled by it: the other is ſo delighted with its warmth, that he uſes it as a bath.

"The ruggedneſs of the road from Taraguagua, leading up the mountain, is not eaſily deſcribed. The declivity is ſo great, in ſome parts, that the mules can ſcarcely keep their footing; and, in others, the aclivity is equally difficult. The trouble of ſending people before to mend the road, the pain ariſing from the many falls and bruiſes, and the being conſtantly wet to the ſkin, might be ſupported, were not theſe inconveniencies augmented by the ſight of

ſuch frightful precipices, and deep abyſſes, as excite inceſſant terror. The road, in ſome places, is ſo ſteep, and yet ſo narrow, that the mules are obliged to ſlide down, without making any uſe whatever of their feet. On one ſide of the rider, in this ſituation, riſes an eminence of ſeveral hundred yards; and, on the other, is an abyſs of equal depth; ſo that, if he ſhould give the leaſt check to his mule, and thus deſtroy the equilibrium, they muſt both inevitably periſh.

"Having travelled nine days in this manner, ſlowly winding along the ſide of the mountain, we began to find the whole country covered with a hoar-froſt; and a hut, in which we repoſed, had ice in it. At length, after a perilous journey of fiſteen days, we arrived upon the plain, at the extremity of which ſtands the city of Quito, the capital of one of the moſt charming regions in the world. Here, in the centre of the torrid zone, the heat is not only very tolerable, but, in ſome places, the cold is even painful. Here the inhabitants enjoy all the temperature and advantages of perpetual ſpring; the fields being conſtantly covered with verdure, and enamelled with flowers of the moſt lively colours. However, although this beautiful region be more elevated than any other country in the world, and it took up ſo many days of painful journey, in the aſcent, it is overlooked, nevertheleſs, by tremendous mountains: their ſides covered with ſnow, while their ſummits are flaming with volcanos. Theſe mountains ſeem piled one upon the other, and riſe to an aſtoniſhing height, with great coldneſs. However, at a determined point above the ſurface of the ſea, the congelation is found at the ſame height in all the mountains. Thoſe parts which are not ſubject to a continual froſt, have here and there growing upon them a ruſh, reſembling the geniſta, or broom, but much ſofter and more flexible. To-

ward the extremity of the part where the rush grows, and the cold begins to increase, is found a vegetable with a round bulbous head, which, when dried, has an amazing elasticity. Higher still, the earth is entirely bare of vegetation, and seems covered with eternal snow. The most remarkable of the Andes are the mountains of Cotopaxi [a], Chimborazo, and Pichincha. On the top of the latter was my station for measuring a degree of the meridian; where I suffered particular hardships, from the intenseness of the cold, and the violence of the storms. The sky around us, in general, involved in thick fogs, which, when they cleared away, and the clouds, by their gravity, moved nearer to the surface of the earth, appeared surrounding the foot of the mountain, at a vast distance below, like a sea, encompassing an island in the midst of it. When this happened, the horrid noises of tempests were heard from beneath, then discharging themselves on Quito and the neighbouring country. I saw the lightning issue from the clouds, and heard the thunders roll far beneath me. All this time, while the tempest was raging below, the mountain top, where I was placed, enjoyed a delightful serenity [b]. The wind was abated, the sky clear, and the enlivening rays of the sun moderated

a This mountain is more than three miles above the surface of the sea. It is a celebrated volcano, one of the eruptions of which is described in Ulloa's Voyage, vol. i. p. 442. Vesuvius, and even Etna, it is to be observed, are mere fireworks, compared to the volcanos of the Andes, which, as they are the highest mountains in the world, are the most formidable also for their eruptions.

b Some of my readers may here recollect Dr. Young's Character of a Good Man, in his eighth Night; in which one would imagine, that he had either copied, or anticipated, the description here given by the ingenious Spaniard:

> With aspect mild, and elevated eye,
> Behold him seated on a mount serene,
> Above the fogs of sense, and passion's storm;
> All the black cares and tumults of this life,
> Like harmless thunders, breaking at his feet,
> Excite his pity, not impair his peace.

the ſeverity of the cold. However, this was of no very long duration; for the wind returned with all its violence, and with ſuch velocity as to dazzle the ſight; while my fears were increaſed by the dreadful concuſſions of the precipice, and the fall of enormous rocks; the only ſounds that were heard in this frightful ſituation".

In compariſon with the dangerous aſcent thus deſcribed by the Spaniſh philoſopher, a paſſage over the Alps, and a journey acroſs the Pyrenees, appear but pretty excurſions. Theſe are the moſt lofty mountains in Europe; but the Alps are little more than one half the height of the Andes, ſome of which we know, from geometrical and barometical menſurations, are upward of three geographical miles, or 19,026 feet, above the level of the ſea. But lofty as are the higheſt mountains on the earth, it has been demonſtrated, that they are nothing compared to its prodigious magnitude. For inſtance, what proportion the thickneſs of a human hair bears to a globe eighty inches diameter, the ſame does a mountain, a quarter of a mile high, bear to the whole globe [a].

Mountains appear, to many, defects and blemiſhes in the earth; but they are certainly of the greateſt ſervice to the wellbeing both of man and other animals. Many creatures cannot live but in particular ſituations; and even the tops of the higheſt and coldeſt mountains are the only places where ſome creatures will live: of this kind are the ibex and chamois among quadrupeds, and the lagopus among birds.—They ſerve as ſkreens to keep off the cold blaſts of the northern and eaſtern winds. They alſo ſerve for the production of ſeveral vegetables and minerals, which are not found in any other ſoil: they enable us to keep thoſe mines dry,

[a] Whitehurſt's Inquiry, ch. xii.

which furnish the most useful metals. Besides, the long ridges and chains of lofty mountains, being generally found to run from east to west, serve to stop the evagation of the vapours toward the poles, without which they would all run from the hot countries, and leave them destitute of rain. Mr. Ray adds, that they condense those vapours, like alembic heads, into clouds; and thus, by a kind of external distillation, give origin to springs and rivers; and, by amassing, cooling, and condensing them, turn them into rain, and thus render habitable the fervid regions of the torrid zone. The supply, moreover, which they give to springs and rivers, by stopping and condensing the clouds, is rendered more copious still by the prodigious quantities of snow by which their summits are crowned. This last circumstance in particular, is noticed by our philosophical poets:

• When mid the lifeless summits proud
Of Alpine cliffs, where to the gelid sky
Snows piled on snows in wint'ry torpor lie,
The rays divine of vernal Phœbus play;
Th' awaken'd heaps, in streamlets from on high,
Rous'd into action, lively leap away,
Glad warbling through the vales, in their new being gay.

THOMSON.

Thus on the soil with heat immoderate dried,
To which the rain's pure treasures are denied,
The mountains more sublime in ether rise,
Transfix the clouds, and tower amid the skies;
The snowy fleeces, which their heads involve,
Still stay in part, and still in part dissolve;
Torrents and loud impetuous cataracts
Through roads abrupt, and rude unfashion'd tracts,
Roll down the lofty mountain's channell'd sides,
And to the vale convey their foaming tides;
At length, to make their various currents one,
The congregated floods together run;

These confluent streams make some great river's head,
By stores still melting and descending fed;
Thus from th' aspiring Mountains of the Moon [a],
Dissolving treasures rush in torrents down,
Which pass the sun-burnt realms and sandy soil,
And bless th' Egyptian nation with their Nile:
Then whosoe'er his secret rise would know
Must climb the hills, and trace his head in snow;
And through the Rhine, the Danube, and the Rhone,
All ample rivers of our milder zone,
While they advance along the flats and plains,
Spread by the showers augmented, and the rains;
Yet these their source and first beginning owe
To stores, that from the Alpine mountains flow;
Hence, when the snows in winter cease to weep,
And undissolv'd their flaky texture keep,
The banks with ease their humble streams contain,
Which swell in summer, and those banks disdain.

BLACKMORE.

But the benefit of mountains, in general, is not only, that vapours driven against them are condensed, so as to be precipitated through the chinks of the rocks, but that afterward, in their bowels, they are preserved, till they form rivulets, and then rivers. Vapours would fall in rain or dew, although there were no mountains; but then they would fall equally, over considerable places of the globe at once, and thus would be sucked deep in the ground, or make a universal puddle. On the contrary, by means of mountains, they are perpetually pouring down in particular places, and treasuring up a constant supply to the rivers. Another considerable use of them is the determination of these rivers; for if there could have been rivers without mountains, yet they could have flowed in a straight line only, if they had flowed at all; whereas, by these eminences placed up and down, they make innumerable turn-

a Mountains in Africa so called.

ings and windings, by which they water and enrich the ſoil of many different countries in one courſe, and at laſt diſembogue, ſometimes in ſeveral mouths, into the ſea. But, not to be too diffuſive, I ſhall conclude, with obſerving, that theſe ſtupendous maſſes are not, as ſome have ſuppoſed, mere incumbrances of the creation, or rude and uſeleſs excreſcences of the globe, but in a variety of inſtances, add greatly to its beauty, and anſwer many excellent purpoſes. In a word, when we contemplate the mountains among the other innumerable diſplays of the goodneſs, wiſdom, and omnipotence of the Univerſal Creator, well may we exclaim with the prophet Habakkuk, "The everlaſting mountains were ſcattered—His ways are everlaſting"; or in the ſublime perſonification of the Pſalmiſt, "Mountains and all hills—praiſe the name of the Lord; for his name alone is excellent; his glory is above the earth and heaven".

LXXVIII. THE CONCLUSION.

The whole up-tracing, from the dreary void,
The chain of cauſes and effects, to Him,
The world-producing Eſſence, who alone
Poſſeſſes being. THOMSON.

IN the conduct of the Contemplative Philoſopher, of which this number is the concluſion, I have wandered into ſome of the moſt fertile regions of philoſophical diſcuſſion, and collected a variety of the wonderful phenomenons of Nature, as rational ſubjects of curioſity and inveſtigation. My young readers, in particular, I have endeavoured to allure to theſe improving inquiries, by ſtrowing, as it were, each winding path with flowers; ſhowing, at the ſame time, how much ſome of the fineſt paſſages in poetry are indebted, for their beauty, to the gay and lively, or to the ſublime, and even terrific images, which are every where ſo profuſely ſcattered. But I have deemed this a conſideration of infinitely leſs moment, than that of inculcating the principles of piety and virtue, by occaſionally introducing ſuch religious and moral reflections as each ſubject had a tendency to inſpire; and pointing out, as the glorious theme of all, the irreſiſtible indications of a Supreme Being, the Great Creator and Governor of Univerſal Nature.

Ere the riſing ſun
Shone o'er the deep, or 'mid the vault of night
The moon her ſilver lamp ſuſpended: ere
The vales with ſprings were water'd, or with groves
Of oak or pine the ancient hills were crown'd;
Then the Great Spirit, whom his works adore,
Within his own deep eſſence view'd the forms,
The forms eternal of created things:

The radiant ſun; the moon's nocturnal lamp;
The mountains and the ſtreams; the ample ſtores
Of earth, of heaven, of nature. From the firſt,
On that full ſcene his love divine he fix'd,
His admiration. Till, in time complete,
What he admir'd and lov'd his vital power
Unfolded into being. Hence the breath
Of life informing each organic frame:
Hence the green earth, and wild reſounding waves:
Hence light and ſhade, alternate; warmth and cold;
And bright autumnal ſkies, and vernal ſhowers,
And all the fair variety of things. AKENSIDE.

It is obſervable, that however oppoſite are the hypotheſes of Atheiſm and Theiſm, there is one common circumſtance in which they agree; and that is, that ſomething muſt have been, from all eternity, ſelf-exiſtent and independent. But the Atheiſt aſſerts, that this viſible material univerſe is that neceſſarily exiſting ſomething. His opinion, therefore, is, that as there is an infinite variety of beings in the univerſe, and a great diverſity of qualities, faculties, and perfections appertaining to the ſeveral kinds of them, yet, that the very loweſt of all, namely, ſenſeleſs paſſive matter, muſt be the firſt principle, the eternal ſelf-exiſtent being, from which, as the ſole independent origin, all things, even the moſt regular and beautiful, aroſe; together with the higheſt perfection of underſtanding, virtue, and felicity, without any active, intelligent, deſigning cauſe. But this hypotheſis is incumbered with inſurmountable difficulties; for it can account for nothing in the whole viſible creation, without attributing it to what is in itſelf nothing, Neceſſity, or Chance. Neither of theſe can account for the beautiful order, proportion, and harmony, ſo viſible in the whole creation; nor for the formation of animal life in ſuch variety of ſpecies, all preſerved diſtinct from each, without confuſion, and propagated by a

ſettled law—each fitted to its own element, provided with proper food for ſubſiſtence, and proper means for procuring it; with ſuitable inſtincts and organs, particularly ſenſation and ſelf-motion, the principal appearances of the ſenſitive life. Nor is it poſſible, moreover, on the atheiſtical hypotheſis, to account for conſcious intelligence, which it diminiſhes into a vain and empty ſhadow, the accidental reſult of the figure of matter and motion; although, as it is this very conſcious intelligence that makes man *himſelf*, nothing can appear to him more real and ſubſtantial.

But the doctrine of a Deity and a Providence is abſolutely the reverſe of this, and explains the ſyſtem of the univerſe in a conſiſtent and ſatisfactory manner. It repreſents intelligence as the firſt of things, the cauſe and origin of all derived beings; and, by the aid of this repreſentation, all things appear in a beautiful and amiable light. A ſupreme, eternal, ſelf-exiſtent mind, immutably poſſeſſed of all abſolute perfections, formed the plan of univerſal creation, and finiſhed it according to his own perfect model; the unceaſing object of admiration to thoſe ſuperior minds, who endeavour to improve their intellectual and moral powers, and, by the ſtudy of Nature and of Nature's God, to riſe to the moſt ſublime heights of ſcience and of virtue.

But not alike to every mortal eye
Is this great ſcene unveil'd. For while the claims
Of ſocial life to different labours urge
The active powers of man, with wiſeſt care
Hath nature on the multitude of minds
Impreſs'd a various bias; and to each
Decreed its province in the common toil.
To ſome ſhe taught the fabric of the ſphere,
The changeful moon, the circuit of the ſtars,
The golden zones of heaven. Some by the hand
She led o'er vales and mountains, to explore
What healing virtue dwells in every vein

Of herbs or trees. But ſome to nobler hopes
Were deſtin'd: ſome within a finer mould
She wrought, and temper'd with a purer flame.
To theſe the Sire Omnipotent unfolds,
In fuller aſpects and with fuller lights,
This picture of the world. Through every part
They trace the lofty ſketches of his hand:
In earth, or air, the meadow's flowery ſtore,
The moon's mild radiance, or the virgin's mien
Dreſs'd in attractive ſmiles, they ſee portray'd
(As far as mortal eyes the portrait ſcan)
Thoſe lineaments of beauty which delight
The Mind Supreme. They alſo feel their force,
Inamour'd: they partake th' eternal joy. AKENSIDE.

It was, indeed, to be expected, that the work of a Divine Architect ſhould bear the ſignature of his hand; that his infinite goodneſs, and wiſdom, and power ſhould be diſplayed in the magnificence and variety, the beautiful proportion and exquiſite harmony of the whole. The whole maſs of extended paſſive matter, in itſelf ſo mean and contemptible, is formed into various beauty, by the energy of ſpirit that pervades it. Hence there is a gradual aſcent to the utmoſt heights of excellence; and in every riſing ſtep of the ſcale we behold a growing diſplay of original perfection. Vegetation itſelf is a wonderful improvement upon dead matter; but animal ſenſation and ſpontaneous volition, however low in compariſon, are ſtrong images of underſtanding and activity. Human intelligence, with its various powers, exerciſes, and enjoyments, is the higheſt in our world, and leads us directly to the Great Original, the Uncreated Mind, by which it was formed. Between theſe two there ſeems to be an immenſe chaſm; but we have reaſon to imagine, that there are intermediate orders of celeſtial beings, ſuperior to us; although the moſt exalted of them muſt ever be at an infinite diſtance from unoriginated excellence.

In the various ſubjects of my preceding papers, the reader muſt have obſerved many ſtriking inſtances, in which the wiſdom and contrivance of a ſupreme directing power were too evident to be denied. In the productions of an infinite mind, much, however, muſt remain for ever incomprehenſible by the moſt enlightened mortal. This, ſo far from being an argument againſt the exiſtence of contrivance and deſign in every thing we ſee, demonſtrates only the infinite diſtance between the underived ſource of all perfection, and the moſt exalted excellence of which human underſtanding can form a conception. Can *we* by ſearching find out God? Can *we* find out the Almighty unto perfection[a]? Yet, although unſearchable his nature, and inſcrutable his ways, enough is known, to excite the moſt awful ſentiments of wonder and adoration. For the inviſible things of Him, who dwelleth in unapproached light[b], even his eternal power and godhead, are clearly ſeen, being underſtood by the things that are made[c]. The heavens declare His glory, and the firmament ſhoweth His handy work. Day unto day uttereth ſpeech, and night unto night ſhoweth knowledge[d].

But I have already expatiated upon this ſublime ſubject[e], and the limits of this paper will not permit me to attempt a more copious diſcuſſion. Nothing can be more improving than frequent meditations on this inexhauſtible theme; nothing more inſtructive than inquiries into the general laws of nature; provided, after all, that the reſult of our reſearches be not the mere gratification of uſeleſs curioſity, or enlargement of the ſources of unprofitable amuſement, but

[a] Job xi. 7.
[b] Par. Loſt, iii. 4. and 1 Tim. vi. 16.
[c] Rom. i. 20.
[d] Pſalm xix. 1.
[e] No. VI. Reflections on the Exiſtence of a Supreme Being.

a deep ſenſe of the infinite wiſdom and power of the Supreme Being; the cultivation of thoſe devout affections which a grateful ſenſe of his unceaſing goodneſs ſhould inſpire; a ſincere and ſteady obedience to his holy laws, in the unaffected exerciſes of piety, the practice of all the moral virtues, and, more particularly, the delightful ſentiment of benevolence, from our own ſmall domeſtic circle, expanding and expanding, till it include the whole human race. Nor ſhould a religious acquieſcence in all the divine diſpenſations be forgotten: it will naturally ſpring from a firm and well-grounded confidence in the overruling providence of God: it will fill the mind with conſolation in calamity, with ſerenity in the more proſperous ſcenes of life, with fortitude in ſickneſs, and with peace, and hope, and joy, even in the moment of diſſolution. But the habits of piety and virtue muſt be formed, not by a few momentary and tranſient ſentiments, but by ſerious and frequent meditations on ſuch ſubjects; and I would fain adopt myſelf, and wiſh all my readers to adopt, the charming language of the poet of the Seaſons:

For me, when I forget the darling theme,
Whether the bloſſom blows, the ſummer ray
Ruſſets the plain, inſpiring autumn gleams,
Or winter riſes in the blackening eaſt,
Be my tongue mute, may fancy paint no more,
And, dead to joy, forget my heart to beat.

THE END.

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